Engineers and Technicians: The Effect of Cognitive Style and Gender on Visual Information Processing

G.R. Lindsey B.A., B.Ed.

Department of Graduate and Undergraduate Studies in Education

(submitted in partial fulfillment of the requirements
for the degree of Master of Education)

COLLEGE OF EDUCATION
BROCK UNIVERSITY
St. Catharines, Ontario
Canada

ACKNOWLEDGEMENTS

I would like to acknowledge the help of my thesis committee: Dr. Len Popp, Dr. Patricia Cranton, Dr, Kris Kirkwood, and Dr. Alan Bennett. Special thanks must go to Dr. Popp for his motivation to pursue excellence in training research.

Furthermore, thanks must go to staff members of Northern Telecom Canada, specifically Department 1928, and Bell-Northern Research who provided support in the creation of my test tools, and in the process of data collection for the thesis. Specifically I would like to thank Shayne Dark for his able assistance in creating the graphics in *SHOW PARTNER* and Denis Thibault for his printing of the graphics.

Finally, I would like to thank my wife, Marjorie, for her encouragement, patience, and numerous examples of academic excellence.

ABSTRACT

The purpose of this project was to identify in a subject group of engineers and technicians (N = 62) a preferred mode of representation for facilitating correct recall of information from complex graphics. The modes of representation were black and white (b&w) block, b&w icon, color block, and color icon. The researcher's test instrument included twelve complex graphics (six b&w and six color - three per mode). Each graphics presentation was followed by two multiple-choice questions. Recall performance was better using b&w block mode graphics and color icon mode graphics. A standardized test, the Group Embedded Figures Test (GEFT) was used to identify a cognitive style preference (field dependence). Although engineers and technicians in the sample were strongly field-independent, they were not significantly more field-independent than the normative group in the Witkin, Oltman, Raskin, and Karp study (1971). Tests were also employed to look for any significant difference in cognitive style preference due to gender. None was found.

Implications from the project results for the design of visuals and their use in technical training are discussed.

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CHAPTER ONE

Project Introduction

Statement of the Problem

The problem in this project was fourfold. There was the need to identify:

1. the cognitive style preference (field dependence) of engineers and technicians;
2. the differential influence of cognitive style (in engineers & technicians) on visual information processing and short term recall;
3. the differential influence of gender (in engineers & technicals) on visual information processing;
4. the implications for the use of visuals (icon & block style graphics) in technical training curriculum.

The cognitive style preference for a sample of engineers and technicians at Northern Telecom Canada's Emerald Plaza technical training facility was identified through the use of the Group Embedded Figures Test (GEFT). Visual information processing and short term recall was tested through the use of a computer display terminal (CDT), a video projection unit, a graphics software package generating graphics and text, and a multiple-choice answer sheet (completed by hand).

Rationale for the Study

The rationale for this study is divided into two parts. The first part identifies the need to clarify why this study was important; the second part identifies how its findings will be helpful. Implications for the use of visuals in technical training curricula are identified through the research findings, and from previous research work done in this field.

Generally, there has not been a great deal of scholarly research in the industrial training field, either in technical courseware design or in learning by the adult learner (e.g., engineer and technician). "Little research has been directed to the development of

O'Donnell, Young, Lambiotte, & Rocklin, 1986, p. 217). Some current industrial training practices can be found detailed in professional training journals, but the rigorous analysis, synthesis, and evaluation normally found in published research, if pursued in industrial training, is usually transmitted informally to the work group and to management. "Unfortunately, there is little time or encouragement to disseminate findings any farther than these immediate work settings" (Encyclopedia of Educational Research [EER], 1982). Often this occurs because training management has little interest in academic research and its application to training needs. Moreover, there is the problem that such research often deals with proprietary corporate information.

In the corporate marketplace where hi-tech competition requires corporations to be "lean and mean", efficient and effective job training is very important. In the article titled "U.S. business pushes job training" (Washington Post, appeared in the Ottawa Citizen, July 14, 1988, Section C, page 15), the author writes that "according to Anthony Patrick Carnevale, chief economist for the American Society for Training and Development, U.S. businesses are spending $210 billion for on-the-job training and education - creating a system about equal in size to the nation's public elementary, secondary, and higher institutions combined." With these large sums of money being spent on training and education, the question that must be asked is this: Is the money being spent on training effective and efficient in terms of meeting the needs of the trainee? The issue pursued in this study is a subset of this question.

It may seem somewhat simplistic, but "the ultimate aim of educational research is to improve the instructional process" (Donald, 1987, p.63). Yet, "to date, very little research effort has been devoted to the isolation, identification, and measurement of those essential stimuli, used both singly and in various combinations in visual illustrations, which are instrumental in increasing significantly student learning" (Dwyer, 1972, pp. 2-3). Furthermore, Siegel (1978) writes that numerous studies have demonstrated the capability of children to recall and recognize pictoral information, but that these studies have also "demonstrated the advantages of pictures as learning aids" (p. 97). It seems, therefore, opportune to research the effects on learning for the adult learner when using graphics in the classroom.

This research project seeks to better the design of technical training courseware, specifically the visuals and graphics used in presentations and student manuals. We know that technical material is typically written in a very dense manner (i.e., with little redundancy or embellishment). We also know that sentences found in technical courseware are uniformly important and contain specialized vocabulary with few metaphors or analogies (although acronyms and abbreviations abound). Importantly for technical courseware, "visual material is often central to understanding. Rather than supplementing text, technical diagrams can themselves require effortful processing..." (Larson et al., 1986, p. 218). It would seem, therefore, that if the design of visuals and graphics can be "tuned" to the predominant cognitive style of engineers and technicians who are learning complex technical material, then the instructional process will have been improved and the body of knowledge enlarged in the study of visuals.

Another article found in the Inside Guide Magazine (1988, Fall) titled The International Revolution in Education also quotes some significant training expenditures (although different from the previous quotation) when discussing the future of education and training. The article's author, John Naisbitt, writes that "corporate colleges at IBM, Rand Corp., Motorola and other major companies now teach 8 million workers, from clerks to top executives, at an annual cost of $40 billion. U.S. companies will spend $60 billion to send 12 million workers to in-house colleges in the next 12 years" (p. 38).

What things will influence the spending of this money? "The major influences on training are financial and non-financial goals of the company involved. Training efficiency and effectiveness are two additional important influences. Measures of these influences often serve as proxies for a companies [sic] financial goals" (EER, 1982).

Obviously, a great deal of money is being spent on training in corporations. The reason for training workers is to make them productive. Although not of primary importance, it is still important to recognize that "... training is a secondary organizational goal that exists to support the production of selected goods and services" (EER, 1982). In order for a corporation to survive and prosper in today's highly competitive marketplace, training dollars must be well-spent (i.e., efficiently and effectively).

An efficient and effective training program with well-researched design methodologies is, therefore, highly influential in the present and future well-being of a corporation. This study should assist in meeting this goal.

Background To The Study

In the past forty years a great deal of study and research has taken place in the area of cognitive style, specifically field dependence-independence. Initial research has indicated that cognitive style preference would have a significant impact on how a student would process information from visuals, both complex and simple visuals. Present day research seems to be finding conflicting results.

Given the enormous rate of growth in technology, research and development, and manufacturing, the training and retraining of technical staff is an important issue. Above all, training must be effective and efficient in altering and enhancing cognitive structures and on-the-job behaviors. With the highly competitive hi-tech marketplace of the last two decades of the 20th century, it is important that training departments in industry be attuned to current psychological theory so that they may develop technical training curricula which meet the needs of the adult learner in the hi-tech work environment.

Although staff members in technical training centers are normally quite familiar with the lecture-based training method, the relatively new technologies of interactive-video and computer-based training are now beginning to mature. The appropriate use of the visual field present in these technologies (while not forgetting the standard hard-copy student manual, overhead visuals, and 35 mm slides) requires further study in an effort to match inherent technological strengths with the target population's visual information processing strategies.

Assumptions and Limitations

The major assumption in the study is that the subject sample is representative of the larger population of engineers and technicians. Subjects from classes held at Emerald Plaza during the months of October to December of 1988 and January 1989 were asked to participate in the study. They could decline to do so if they wished. Since these subjects were engineers and technicians from either Northern Telecom, Bell-Northern Research, or telephone companies, they should represent a good cross-section of their target population. Their attendance in the training classes was based on job/task requirements and career pathing. Their selection for the experiment was based on invitation, lab availability, hardware working order, and other vagaries of experiment and training center coexistence.

Limiting factors of the study are the validity and reliability of the GEFT (reliability is .82), and the test instrument (graphics and multiple choice questions) constructed by the researcher. The correctness of test instrument graphics was validated by a subject matter expert, and although the number of elements per graphic was not held constant, the small range in the complexity of graphics was not considered to be a factor that would affect recall.

Finally, it is possible that some subjects who have worked with the Integrated Services Digital Network (ISDN) used an advance memory factor which may have assisted in the recall of answers. This threat to validity was also considered to be small. This conclusion was based on the running of ALPHA and BETA tests prior to the experiment's sessions, and these tests indicated to the experimenter that most subjects used recall information from the graphics when answering the multiple choice questions. Furthermore, the range of complexity in the graphics was not raised as a significant confounding factor during the ALPHA and BETA tests.

There may be a threat to validity (history) due to the length of the test period. Subjects at diverse locations may have discussed the contents of the experiment. The experimenter felt that this was unlikely to happen.

<u>Definition of Terms</u>

Arbitrary picture: - a two dimensional image which manifests, but does not look like, the object or concept.

Block diagram: - a 2 or 3-dimensional representation of geometic figures portrayed in two dimensions.

Cognitive controls: - intellectual structures which are essential attributes of personality organization and which function automatically in a consistent pattern; similar to cognitive style.

Cognitive style: - characteristic modes of functioning that are revealed through perceptual and intellectual activities in a highly consistent manner.

Courseware: - student manual, instructor guide, audio-visual material (e.g., overheads), exercise work, and evaluation tools.

Field articulation: - the ability to direct attention selectively without being distracted by competing, irrelevant stimuli.

Field dependence: - a dimension of cognitive style; the perceptual dimension of cognitive style.

Icon: - a figure, image, or representation.

Illustrative material: - tables, graphs, and diagrams.

Integrated Services Digital Network (ISDN):
- an international telecommunications standard which allows for the interconnection of computing and telephony devices from various manufacturers so that they may share telephone, data, graphic, and video services.

Psychological differentiation:
- self-nonself dichotomy; the ability to pull oneself out of context/field; autonomy of external referents.

Representational picture:
- a 2 or 3-dimensional physical resemblance of an object or concept; often referred to as an "analog" picture.

Hypotheses

There were four hypotheses tested.

H1: Based on the Group Embedded Figures Test, engineers and technicians will be found significantly more field-independent than the population identified in the Group Embedded Figures Manual.

H2: On a test of short-term recall (multiple choice) administered while viewing a series of complex graphics, there will be no significant difference in the recall of visual information between male and female engineers/technicians.

H3: On a test of short-term recall (multiple choice) administered while viewing a series of complex graphics, engineers and technicians (male & female) will be able to recall more information from b&w block (BB) mode graphics than b&w icon (BI) mode graphics.

H4: On a test of short-term recall (multiple choice) administered while viewing a series of complex graphics, engineers and technicians (male & female) will be able to recall more information from color block (CB) mode graphics than color icon (CI) mode graphics.

Summary

In this study, the research involves engineers and technicians as subjects. In order to facilitate their learning while taking technical training courses in business and industry (or courses at university and community colleges), this study hopes to identify a preference for a specific type of visual or graphic.

As noted, business and industry spends large sums of money on training. For individual companies or corporations, this money must be spent effectively and efficiently in order to maintain a competitive edge in the marketplace. Therefore, a great deal more scholarly research must be pursued in business and industry where both the subjects and the context of training are congruent with the research needs.

This study hopes to facilitate the above research needs, and thereby increase the amount of information in the research database on the subject of industrial training. In doing so, it is hoped that engineers and technicians may benefit from future courseware "tuned" to their cognitive style and learning needs.

CHAPTER TWO

Search Of The Literature

Introduction

There is a large body of research in the study of cognitive styles. There are literally thousands of papers in the public domain. Knaak (1983) lists nineteen dimensions of cognitive style (see Appendix 1). When "learning styles" are considered, there are still many more studies.

The review of the literature for this research project focuses on the field dependence[1] cognitive style. The ultimate purpose of this review is to help shed some light on how cognitive style affects human visual information processing. Ultimately, this new understanding may help with the development of visual learning materials in technical training.

This review has four sections: The first section examines some conceptualizations of cognitive style; the second reviews the history of H.A. Witkin's work on the field dependence construct; the third section examines field dependence and visual information processing; the fourth section examines the educational implications of how the cognitive style construct may aid in learning.

Cognitive Styles: Some Conceptualizations

"The most pervasive problem in the cognitive styles field is that the concept of cognitive style, in general and in particular, has been poorly defined. As a relatively recent addition to psychology's collection of constructs, the concept has not been

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[1] For purposes of consistency throughout this project, *field dependence* is used as the term describing the cognitive style as identified by H.A. Witkin. It may be found as *field independence* and *field dependence-independence* in some of the quotations.

integrated as a whole into any of the dominant theories, nor has a new theoretical system been developed to accommodate them" (Shipman & Shipman, 1985, p. 259).

The central factor in the definitional problem of "cognitive style" is due to the many disparate research trends in this field of study. Research studies in intelligence and cognitive style, ability and cognitive style, and conceptualization and cognitive style has produced a plethora of styles. "Over the years a variety of characterizations of cognitive style have been proposed, which is one source of confusion in the field" (Messick, 1984, p. 60).

It seems that "the identification of styles came before the formation of a theoretical structure about the nature of cognitive style, with the resulting diverse conceptions of the boundaries and function relationships for the construct as a whole" (Shipman & Shipman, 1985, p. 260). Although the results of such an unstructured approach to the research into cognitive styles may seem to be chaotic, in fact, much fruitful work is being done. For the experimenter, though, "all of these disparities in labels and conceptions call for an attempt to develop some kind of consensus, if that is possible" (Guilford, 1980, p. 726). From this "it would seem worth the effort to review them systematically to highlight the key convergent features" (Messick, 1984, p. 60).

Styles - Field Dependence - the clearest conceptualization

Fielddependence was the first conceptualization of cognitive style. Through Witkin's research, it was first defined in terms of perception and the ability to restructure a visible field. "The cognitive style called 'field-independence' taps a dimension called cognitive restructuring" (Carrier, 1984, p.17). Highly field-independent persons tend to restructure a stimulus field (i.e., they do not accept the field as is, but actively think about the field's structure and underlying concepts, and fit them into their previously created schemata) when it is beneficial to do so. On the other hand, highly field-dependent persons tend to accept and work with a stimulus field as it is given.

This concept was further extended to include field articulation (i.e., the ability to separate components of a stimulus field, disembed the components, or selectively focus on the components) and psychological differentiation (self versus nonself).

Styles - Structural Properties of the Cognitive System

In this representation of cognitive style, style refers to consistent individual differences in the nature of cognitive structure. Complexity versus simplicity is a cognitive style identified by this representation. Complexity "is generally recognized as a preference for complex conceptions over simple ones" (Guilford, 1980, p. 722). As an example, in sorting tasks, individuals who define a large number of differentiated classes have scores that are in the direction of complexity, whereas individuals who define a small number of inclusive classes have scores in the direction of simplicity.

The degree of conceptual differentiation, articulation, or hierarchic integration of cognitive units can also be viewed in this style as being either cognitively complex (high differentiation, articulation, and integration) or cognitively simple (low differentiation, articulation, and integration). Cognitively complex individuals are not as concerned with permanent boundaries or classes, whereas cognitively simple individuals feel more comfortable with relatively permanent boundaries around concepts. Cognitively complex individuals also enjoy diversity. They seem to be more effective and certain in processing dissonant information. On the other hand, cognitively simple individuals prefer regularities in their environment and are more confident and perceptive in processing undifferentiated information.

Style, therefore, may be considered as those "internal rules and principles of mental organization reflecting one's level of cognitive development or maturity, and affecting processing in a broad-based manner through alterations in cognitive structure" (Shipman & Shipman, 1985, p. 232).

Styles - Modes of Information Processing

Two major conceptions of style are prominent in this representation: leveling versus sharpening, and scanning versus focusing. These conceptions define cognitive style as "self-consistent characteristic modes of perceiving, remembering, thinking, and problem-solving" (Messick, 1984, p. 60).

Leveling and sharpening refer to the blurring versus magnifying of differences between stimuli in memory. "One of the prominent hypotheses concerning the trait of

LS (leveling and sharpening) regards it as a matter of assimilation of perceived information to remembered information" (Guilford, 1980, p. 726). Leveling individuals smooth over irregularities in memory, whereas sharpening individuals exaggerate outstanding features. In effect, leveling collapses over time stimulus differences into a simpler schemata while sharpening heightens the stimulus differences into a more complex schemata.

Focusing versus scanning "refers to individual differences in the extensiveness and intensity of attention deployment" (Messick, 1984, p. 60). "Attention is a matter of preparation for cognition, or for other operations in general, rather than being a modifier of those operations" (Guilford, 1980, p. 727). An individual who scans will not have the same vividness of experience as a person who focuses on stimuli. The person who scans, however, may have a larger span of awareness.

Style - Other Sundry Conceptualizations

There are a number of other conceptualizations of cognitive style: cognitive preferences (broad versus narrow stimulus categories), preferred decision-making strategies (risk-taking versus cautiousness), strategies of learning and knowledge acquisition (holist versus serialist), and attitudes towards thinking, learning, and intellectual activity (theory versus practical application, and analytical versus global).

All of these conceptualizations are not mutually exclusive. They overlap in certain instances, and at other times can be simultaneously characterized in more than one way. Field dependence is a prime example. The field dependence style and the analytical/global style share the same terms (e.g., "analytical" and "articulated"). Both of these terms, along with "global" and "undifferentiated" are used interchangeably to describe both styles.

Finally, Messick defines a conceptualization of cognitive styles that emphasizes three points: cognitive styles are dimensions of continuous variation; cognitive styles are sign posts for characterizing individual propensities; and cognitive styles are tendencies and tensions underlying the surface of intellectual life.

<u>The History of the Field Dependence Construct</u>

During the second world war, it was noticed that some fighter pilots would emerge upside-down from the clouds after a dogfight. How could some pilots retain their sense of upright, whereas others could not?

H.A. Witkin, the father of cognitive style research, began his studies in 1942 during World War Two. The question for which he sought an answer was, How important were visual cues in perceiving the vertical direction of space? "Ordinarily, the standard derived from the visual field and the standard derived from the body coincide in direction, and complement each other to give us an accurate sense of the location of the true upright" (Witkin, Moore, Goodenough, & Cox, 1977, p.2). In order to help answer this question, his research needed a test that would create a conflict between visual and gravitational cues. Witkin wrote that "in our early experiments we eliminated the complex visual world in which we live and substituted for it a simpler, more manipulable visual framework; at the same time we separated the visual and bodily standards" (p. 2).

The Rod-and-Frame Test (RFT) was the major instrument used in the early research. In this test the subject was seated in a completely darkened room and viewed a luminous rod suspended in a luminous frame. The conflict was created when the luminous frame was tilted. "The importance of visual cues in resolving the conflict was measured by asking subjects to adjust the rod to the vertical position" (Goodenough, 1986, p. 5). "Important for the issue of styles was the early finding of marked individual differences among people in how they perform this task" (Witkin et al., 1977, p. 3).

Other tests were developed around the same time. These tests included the tilting-room test (Body Adjustment Test - BAT) and the rotating-room test. Generally, however, these tests could only be run with a limited number of subjects, and therefore constrained research.

Another test developed and used by Witkin in the early years was a speed test called the Embedded Figures Test (EFT). When writing the EFT, the subject was required, after viewing a simple geometric figure, to trace that figure within a complex background. "For people at one extreme the sought-after figure quickly emerges from the complex design, whereas people at the other extreme are not able to identify the simple figure in the time allowed for the search" (Witkin et al., 1977, p. 6). Although this test was also administered to individuals, it was much simpler to use, and facilitated testing for field dependence.

At first, performance on the EFT was narrowly defined as reflecting the perceptual dimension of field dependence. At issue was the degree of adherence to a predominant context. But "when performance on this task was found to be related to performance on non-perceptual intellectual tasks, the underlying construct was broadened to a global-articulated dimension, a dimension on which individuals differ in their tendency to structure their perceptual field" (Goldstein & Blackman, 1978, p. 175).

Witkin realized that people showed a remarkable self-consistency in degree of field dependence across numerous tests of orientation perception. "With this finding, field-dependence achieved the status of a construct, referring to the cross-situational communality" (Goodenough, 1986, p. 6).

Perhaps the most startling discovery was that personality was somehow related to the perception of the upright in space. Over the years research in the literature has identified a number of personality correlates of field dependence, the most important involving social-interpersonal behavior. "Particularly impressive is the evidence of differences in characteristics falling in the domain of social behavior between people with relatively articulated or relatively global style" (Witkin et al., 1977, p. 10). Field-dependent people were found to be more socially oriented. They paid greater attention to interpersonal cues. Examples of this more-socially sensitive "radar system" was the field-dependent's preference for being physically close to people, looking at people's faces more often, and displaying greater emotional openess in their conversation with others.

This style was evident in most day-to-day situations. "For example, the person who, in the laboratory, is strongly influenced by the surrounding visual framework in his perception of an item is also likely, in social situations, to use the social frame of reference to define his attitudes, his beliefs, his feelings, and even his self-view from moment to moment" (Witkin, 1976, p. 43).

Field-dependent persons were also found to be especially prone to guidance by the positions attributed to an authority figure or peer group. "Reflecting their use of external sources of information for self-definition, field-dependent persons are selectively attentive to the human content of the environment" (Witkin, 1976, pp. 43-44).

In contrast to the field-dependent person, the field-independent person was found to have a more abstract, impersonal orientation. Generally, the field-independent person was found not to be as sensitive to social undercurrents, and were colder and more distant in their social interactivity. "They are not usually very interested in others, and they show greater physical and emotional distancing. In sum, field-independent people seem to function with a greater degree of individual autonomy in their social-interpersonal behavior" (Goodenough, 1986, p. 7).

As research continued into field dependence, more and more general constructs were introduced to account for the data. When evidence was found of relationships between field dependence and organizing abilities in problem-solving tasks, the articulated-global dimension was introduced to describe this communality. Indeed, as evidence accumulated on field dependence and personality, the differentiation construct was introduced.

In 1962, H.A.Witkin published a book titled Psychological Differentiation. In this book, degree of differentiation was considered to be a major formal property of an organismic system. Moreover, in Witkin's thinking, the related constructs were organized into a pyramidal form, and the differentiation construct was found at the apex. Field dependence was a very specific construct defined as a disembedding ability in perception, and it was located near the base of the pyramid. "In this view, field-dependence was an expression of a more global or undifferentiated mode of cognitive functioning, and field-independence was an expression of a more articulated, or differentiated mode" (Goodenough, 1986, p. 8).

A more differentiated system was said to be in a relatively heterogeneous stage, with a greater separation of activities from each other within the system. Furthermore, such a system had "a greater specialization of function, and a greater self-nonself segregation involving clear boundaries between an inner core of attributes, feelings, needs, and the outer world" (Goodenough, 1986, p. 8).

In the separateness of self from nonself, field-independent people were said to have a self which was experienced as segregated and structured. They have available distinctive internalized frames of reference. Furthermore, these characteristics, as previously noted, defined the field-independent person as articulated.

From the differentiation theory and the more general constructs in the pyramid, more hypotheses were generated about the field dependence dimension and other correlates. "The growing network of data was used, in turn, to modify and expand the theoretical framework" (Goodenough, 1986, p. 8).

In the 1960s, 1970s, and 1980s the differentiation theory spawned research in the field of cerebral lateralization. It seemed possible that the increasing separation of psychological functions might be reflected in the increasing specialization of cortical functions which controlled those psychological functions. Moreover, there seemed to be research evidence to suggest that field dependence in orientation perception might be due to a visual driving of the vestibular system (Goodenough, 1986, p.10).

Also, a great deal of research began in the cross-cultural domain. Initially the thrust was in the comparison of cultures to test certain hypotheses about socialization factors in the development of field-independence. As research work continued, more emphasis was placed on the adaptive advantages of field-dependent and field-independent ways of functioning in different cultural settings (Goodenough, 1986, p.12).

From this wealth of work and research, Witkin redefined field dependence as a dimension of autonomy, or self-nonself differentiation expressed in upright perception, and in social functioning. At this point, the question had become, What sources of information does a person require to solve ambiguities (e.g., tilted frames)? Field-dependent people seemed to require more data perceived from the world and people around them. On the other hand, field-independent people were more data selective and analytical, and relied on their own abilities to restructure data in order to solve problems. "Embedded-Figures Test performance was also reinterpreted in terms of separate, but related disembedding or restructuring dimension, representing the expression of greater differentiation in the cognitive ability domain" (Goodenough, 1986, p. 11).

Finally, through the continued search for a more unified view of cognitive style, the field-dependence construct had in fact changed position in the pyramid of constructs. From an initial view that the field-dependence construct was a specific description of performance in perceptual tests, it had been redefined as a more general dimension of self-nonself differentiation.

Field Dependence and Visual Information Processing

Memory and Recall

Davis and Cochran (1982) have argued that cognitive style researchers have not exploited fully enough the numerous information processing paradigms. "The vast majority of studies examining field dependence have not fully capitilized [sic] on the theory and methodology afforded by information processing models" (p. 8). This position is also argued by Robinson and Bennink (1978). "We believe that information-processing paradigms can contribute significant insights into the functional determinants of cognitive style... and a closer examination of the interactions of other cognitive states and processing strategies could lead to a fuller explanation of such individual difference dimensions as field articulation" (p. 448). When discussing the development of pictoral comprehension, specifically the morphological similarities of a picture and its three dimensional referent, Siegel (1978) suggests that "the comprehension of pictures involves more than an awareness of morphological congruence between the two sets of stimuli. The inference here is that categorizing stimuli, in addition to recognizing them involves cognitive processing" (pp. 102-103).

Attention Stage

The first stage of visual information processing is the attention stage. This cognitive process is task dependent, and is correlated, as numerous studies show, with field dependence. Robinson and Bennink (1978) noted that field dependence is correlated with performance across a wide variety of attention-related tasks and situtations. They write that "this may be taken as implying that some obligatory aspect of information processing is entailed. In other words, some central component of man's information processing system is mediating cognitive style effects in the tasks studied" (p.40). The question is therefore, How do the processes of attention, encoding, short-term memory, and long-term memory storage mediate the cognitive style of field dependence?

Typically, researchers have started their studies by correlating EFT or GEFT results with various measures of attention including visual search tasks. This line of research has led to revelations that field-dependent subjects are less effective on attention tasks.

Of specific interest to this project was the finding that "field dependent subjects tend to be less effective in signal detection accuracy when the demands of the task are high" (Davis & Cochran, 1982, pp. 2-3, from Forbes & Barrett, 1978). Robinson and Bennink corroborate these results in their study on working memory and field articulation. When field-dependents are given memory tasks under high information load conditions, both their response time and the number of errors are greater than those of the field independent subjects. Shaffer and Shiffrin (1972) in their study on rehearsal and storage of visual information noted that visual rehearsal seems to assist subjects when there is low information content. But "when information content is high, visual rehearsal may not be an effective device" (p. 295).

In tests where field-dependent subjects are required to attend to relevant stimuli in the presence of competing or irrelevant stimuli, they make more errors than field-independent subjects. Davis and Cochran (1982) asked if the differences between field-independent and field-dependent learners are due to different strategies, different processes, or difference in capacity to attend to the demands of a particular task? Berger and Goldberger (1979) seemed to think that field-independent people are generally more focused and more task oriented. "A field-independent person's ability to assume a task appropriate attentional set more readily than a field-dependent person helps explain his superior performance on the interference tests. He is able to approach tasks in a manner designed to maximize his performance..." (pp. 94-95). Rosett, Nackerson, Robbins, and Sapirstein, (1966) wrote that the "ability to direct attention selectively does appear to be necessary to cope with the demands of engineering school" (p. 1150).

The results from the aforementioned studies are consistent with Goodenough's research (1976). His work on cue salience identified that field-dependent subjects are dominated by salient cues in a stimulus complex. Unlike field-independent subjects, field-dependent subjects do not sample fully all of the cues, and they have problems restructuring the stimulus complex (field). Therefore, the more complex a stimulus field becomes, the less likely that field-dependents will be able to sample efficiently the stimulus field, and restructure the field. This inability to sample efficiently and to restructure the field will affect both short-term memory and long-term memory recall.

Encoding Stage

Differences found in cue sampling (i.e., strategies that assist in the perception of information which is embedded in a stimulus field) mimic those differences in concept-attainment strategies. The *holist* strategy employed by field-independents is identified by the ability to accept all values for all attributes in the constructing of an hypothesis. When a value for an attribute changes, that initial value is eliminated, and the hypothesis is reconstructed. This process continues until the correct hypothesis is achieved. In the *partist* strategy, though, the field-dependent uses only some of the attributes to construct an hypothesis. If the hypothesis is disconfirmed, a new hypothesis is constructed using attributes from both hypotheses.

Witkin (1976) stated that "the individual who can not keep an item separate from the surrounding field is also likely to have difficulty with the kind of problem that requires taking some critical element out of the context in which it is presented and restructuring the problem material so that the element is now used in a different way" (p. 42).

Davis and Frank (1979) noted in their work that "part of the problem encountered by field-dependent individuals was in processing information following a wrong outcome" (p. 472). Furthermore, "this finding suggests that part of the deficit in field dependent students' performance may be due to differences in encoding or utilizing negative information. It is possible that field-independent and field-dependent students employ different encoding strategies or that they employ the same strategy but with differential results" (p. 472).

Long-Term Memory

Paivio (1974) has proposed a dual-code hypothesis for cognition and long-term memory. This hypothesis proposes that information is stored in two ways: 1) as a verbal, articulatory string, and 2) as a visual image.

Gagne (1985) has written that

> a large body of research appears to support the dual-code hypothesis. This research shows that words, sentences, and paragraphs that are highly imageable (concrete) are recalled better than those which are less imageable (abstract). It shows that when people are instructed to image the information they are learning, they often remember it better than when they are not so instructed. According to the dual-code hypothesis such results occur because the concrete or imaged materials have two representations in long-term memory (a verbal string and a visual image), whereas the abstract or non-imaged materials have only one representation in long-term memory (a verbal string) (p. 63).

How this dual code-hypothesis interacts with the work on cognitive style is unclear since it is not dealt with directly in the literature. A number of points, though, can be inferred.

Davis and Cochran (1982) noted from the work of Davis and Frank (1979) "that results from free recall studies showed: a) that field independent learners tend to cluster more than field dependent learners, b) that word lists with more difficult patterns are recalled better by field independent learners, and c) the field independent learners have better recall when given the opportunity to organize the material" (p. 6).

It seems logical that if field independent persons cluster words more than field dependent persons, then their complementary visual image or representation will also be clustered, and possibly better organized. Furthermore, the field independent persons ability to better recall word lists with more difficult patterns should also be mimicked by the ability to recall more information from complex visual images.

Paivio and Begg (1974) in their research work on pictures and words in visual searchhave written that

> where the comparison involves simple line drawings and their printed names, a search through pictures might be favored because differentiation among items and identification of a particular item are possible on the basis of relatively abstract features.... each word, however, is a unique configuration of elements shared by other words... (p. 516).

It seems that visual search, and possibly encoding and recall, is facilitated by the initial stimulus of pictures. "The picture-picture condition should have a small but consistent advantage over the word-picture condition , simply because Ss are more likely to generate variable images with words than pictures as stimuli" (Paivio & Begg, 1974, p. 516). As an example, when the word "tree" is read, the reader may visualize a large oak tree; but another reader may visualize a small spruce tree. Furthermore, when the word "tree" is read, visualized as an oak, and then searched for amongst numerous other images, if the "tree" image is that of spruce then the search will take longer. In fact, it is entirely possible that the search might fail because of the variable image produced by the word "tree". A picture of a tree is encoded by its visual structure, and therefore is less likely to produce variable images.

The dual-code hypothesis is a strong imagery hypothesis where stimulus items are more effectively stored as images than words. The recall process becomes more effective when a memory image can be compared directly with pictorial items. "The advantage of a dual code is that if one memory trace is lost another is still available; hence memory is better than if only one memory code is used" (Gagne, 1985, p. 64).

The dual-code hypothesis is, naturally, not the only model for long-term memory. Organizing information from stimuli into schemata is another way to perceive long-term memory. Davis and Cochran (1982) noted in their work on field dependence and an information processing model that "organizational processes do contribute to differences between field independent and field dependent learners" (p. 7). At the same time, the stimulus must be reasonable and comprehensible, otherwise the information being attended to can not be elaborated (i.e., manipulated in working memory and placed in long-term memory). Schemata can then be constructed that would facilitate the "encoding and retention of spatial relations among objects" (Mandler & Parker, 1976, p. 39). Bower, Karlin, and Dueck, (1975) have written that if a learner "comprehends the picture - achieves a compact interpretation of it - then he should remember it much better than if he fails to comprehend it" (p. 216).

The field-independent person is more capable of structuring a poorly organized stimulus field, and elaborating on it. This means that for long-term memory and recall, the field-independent person should recall more information from a previously encountered stimulus field.

Color and Black & White Effects

For over twenty years Francis M. Dwyer has been a leading researcher in the field of visual illustrations for education and training. Her landmark book, A Guide for Improving Visualized Instruction (1972), provides a scholarly focus for this project.

Dwyer considers color to be a significant contributor to the realism continuum for visual illustrations. Her recent research verifies this belief. "How color is used in instructional and testing materials is an important stimulus variable, especially if we want learners to perceive and interact with the critical content in the instructional visualization" (Lamberski & F.M. Dwyer, 1983, p .9).

As a stimulus variable color is considered by C.A. Dwyer to be very important. Color affects both the emotions and the physiology of viewers. As an example, the color red seems to produce more anxiety, whereas blue and yellow produces less anxiety (as measured by galvanic skin response). Red seems also to produce in many humans a greater state of alertness or jitteriness; green produces calmness and relaxation. Furthermore, in studies of complex visual displays (complexity defined by the number of elements in the displays), it has been noticed that there is "decreased alpha activity and increased beta activity. Alpha waves are generally considered to be *slow* waves associated with relaxation, while beta waves are the *fast* waves" (p. 112).

If color is considered a mediating variable when viewing illustrations, cognitive processing of some sort must be involved. If this is a good assumption, cognitive style must also have a role to play in the viewing of illustrations. "In a study involving discrepant visuals, Donohew, Parker, and McDermott found that open-mined persons exhibited more tension from inconsistency in a visual (as measured by galvanic skin response [GSR]) than did dogmatic, or close-minded, persons" (C.A. Dwyer, 1986, p. 113). If open-minded persons are equated to field-independents, and close-minded persons are equated to field-dependents, then the self-nonself dimension of field dependency indicates that close-minded persons have problems differentiating themselves from the confusion of process and content in viewing discrepant visuals. On the other hand, field-independents, being more open-minded, are able to differentiate more easily themself (self) from the discrepant visuals (nonself). They would, therefore, be less tense.

In the Lamberski and F.M. Dwyer experiment (1983), there was a significant main effect for color versus black and white presentation material (instructional booklets). It was found that the subjects who received the color booklets for study during self-paced instruction achieved significantly greater mean scores on a posttest. Color seemed, therefore, to aid in stimulus acquisition and achievement on the posttest. Interestingly enough, on a follow-up retention test those same high scoring subjects forgot just as much information as did those subjects who had received black and white instructional booklets.

C.A. Dwyer, in reviewing the literature on visual stimuli, noted that Borg and Schuller (1977) used a survey to query subjects on their attitudes towards visuals in lessons. "Their analysis indicated that the use of complex art over simple line drawings contributed nothing to the subjects [sic] attitude toward the lesson" (1986, p. 114). On the other hand, Lamberski and F.M. Dwyer's work (1983) with color preference found that "a learner's preference may affect learning by directly influencing attention or motivation" (p.18).

In her book, F.M. Dwyer quotes an earlier personal work. "One assumption for the use of color in media is that it increases the attractiveness of the material by making it more attractive, thereby evoking more attentive behavior on the part of the learner" (1972, p. 8). Her later work with Lamberski confirms this view. "The more visual color code in instructional materials enabled greater concept acquisition, greater availability at retrieval, and a memory decline rate similar to that of the black/white instructional treatments" (1983, p.19).

Research with young adults (grade 12) by F.M. Dwyer found that "detailed, shaded drawing presentation (Colored) was more effective than detailed, shaded drawing presentation" (B&W) (1969, p. 31) in facilitating student achievement on identification tests. Her later research indicates that this result is also found with older adults. Siegel (1978), however, found that color as a cue property was disregarded by young children in sorting tasks where there were diverse class memberships among items. "Since class differences were more salient than similarities in color, color was not seen as relevant" (p.101).

Finally, C.A. Dwyer has written that "the new electronic communication systems (micro-computer, videodisc, laser technology, fiberoptics, etc.) are exploding in their popularity, and their use is permeating instruction and training at all levels. These new communication systems have the capability of optimizing the potential of the visual medium in intensities which heretofore were unthinkable" (1986, p. 115). As with any new technology with its attendant modes of presentation, when applied to the education and training context, continued research will be required to make optimum use of its mediating effects in student learning and training.

Gender Effects

The Witkin et al. (1977) study is an excellent overview of Witkin's work in field dependency including a discussion of sex differences and cognitive style. This comprehensive literature review places a strong emphasis on the importance of the study of field dependence, sex differences, education, and career choice.

"The well-documented evidence of small but persistent sex differences in field dependence-independence among adults suggests that it may be useful to examine the interests-choice-performance domain, in relation to cognitive style, for men and women separately" (Witkin et al., 1977, p. 57). Witkin was studying (as are his present day followers) how men and women in an educational context developed an interest in certain fields, how they made their choice to enter into studies in those fields, and, finally, how they performed in their studies. Central to his interest was the interplay of cognitive style and sex-role assignment.

In his early work, Witkin observed that performance by women on the Rod-and-Frame test (RFT) was significantly more field-dependent than field-independent. Even after some practice during which time the women become more accurate in their RFT performance, the test subjects reported that they still were not comfortable with their responses. The writings of Witkin emanating from this early work on the theory of field dependency appeared to reflect an assumption that the style of field dependence was generally unmodifiable within subjects. This may not be the case.

Further work by Witkin, Goodenough, and Karp (1967) in later longitudinal studies with young people indicated that "the sex difference for the RFT is significant for the 8-13 year group does not reach significance for the 10-24 year group, although it is in the expected direction. The overall tendency for males to be more field independent is consistent with results of many other studies" (p. 297). In this study, however, the stability-over-time dimension of the field dependence is not defined in terms of a "cradle-to-grave" timeline. There seemed, in fact, to be a series of human growth cycles identified by the socialization of the person. Within these cycles there seemed to be some stability of cognitive style.

"One of the more readily accepted explanations for the sex difference in performance on field-articulation tasks rests on the assumption that females are more psychologically dependent and that leads them to take a less active approach in dealing with field-articulation tasks and to achieve a more field-dependent performance" (Sherman, 1974, p. 1225). The question that must be answered is this: Is the difference in task performance due to socialization alone, or are there other factors?

Copeland (1983) writes that "the finding of perceptual differences associated with their biological sex supports the conclusion that the difference is a basic one in the psychological organization of the person" (p.439). The differences between females and males is in part due to the susceptibility to the pervasive influence of their surroundings. Youngsters are influenced by their homes, parents, and schools; adolescents are strongly influenced by their peers and the media; and adults are influenced by the institution of marriage, jobs, and retirement.

Trends in cognitive style change seem, therefore, to be evident in human growth cycles. From the study by Witkin et al. (1967) comes the suggestion "that the trend toward reduced field dependence is progressive from 5 to 17 years" (p.299). This trend may be construed as the progressive "loosening of the apron strings". Until now this process seems to have favored males with the opportunity to move from a field-dependent mode of perception to a more field-independent mode. Will more young females be afforded this opportunity?

In a more recent study, Copeland (1983), citing Witkin's work, stated that "with greater value on women's contribution, there is likely to come less emphasis on obedience on women's part and a greater sense of separate identity - in other words, greater self-nonself segregation and, as a manifestation of it, more field-independent functioning" (p. 440). Therefore, young females at an earlier stage may have the opportunity to differentiate their self from their nonself, and make personal, academic, and career decisions that are congruent with their own personal, internal needs.

Although there is a growing appreciation for women's contributions in the family, academic, and corporate arenas, much work is yet to be done in the training field. Wittig, Sasse, and Giacomi (1984) cite some very serious concerns about training programs for women. "Surrounding the task of training women for careers in engineering and science are a number of controversial issues. Why are there so few women in these careers? What cognitive and affective skills contribute to success in these fields? Can these skills and attitudes thus identified be systematically taught?" (p. 538)

Before briefly addressing these questions, is it possible that there are developmental differences (versus just socialization differences) that account for gender differences in perceptual behavior? Bagnara, Simion, Roncato, and Umilta (1980) found in a study of 16 subjects (8 male, 8 female) that there was a significant first order interaction between sex and visual field. An analysis of variance of mean correct response times found that "male subjects RTs were faster in the left than the right visual field (772 vs 821 msec.) while for female subjects there was a superiority of the right visual field (791 vs 813 msec.)" (p. 227). This study seems to indicate that there is a "significant interaction between sex and visual field which suggests a sex-related difference in hemispheric specialization" (p. 227).

In a study of EFT and sex differences, Bieri, Bradburn, and Galinsky (1958) considered the differences to be a function of the ability to combine more effectively mathematical aptitude and conceptual approach to stimuli. Overall the 50 males found significantly more simple forms with quicker times than did the 62 females. Furthermore, since the study also used a number of other standardized tests, it is important to note the within the male subject group, the more field-independent males performed better on the Barron-Welsh Art Scale. It was found that for the male subjects there was a "significant correlation between EFT scores and Art Scale performance. Those men with faster EFT solution times tended to have greater preferences for the complex figures" (p.6).

When reading the Bieri et al. (1958) study, the question arises as to whether aptitude should be considered a function biological development, or a function of socialization. It may be a little bit of both.

Pictorial Effects

In discussing visual presentation information in formal learning situations, D.M. Moore (1985) has written that "if data can be produced which supports the idea that for certain learning tasks and certain cognitive types, a specific format is effective then instructional developers would be able to utilize the results in alternative media design" (p. 180).

In recent years the evolution of the research database of work with medium (visual) characteristics, cognitive style, and learning tasks has spurred more innovative work with the newest hardware and software technologies. In order to benefit from both the previous research and today's new technologies, present-day research must refine its focus. It has been noted that training in business and industry has not received a great deal of research attention. That being the case, more scholarly attention must be paid to the process of training in business and industry. By focusing on the needs of specific target populations, such as engineers and technicians, the collected data may be valuable in a more directly applicable fashion. Unfortunately, in many cases studies with undergraduate students have done little to aid in the research for more effective and efficient courseware design in industry.

That concern notwithstanding, Holtzman and Swartz (1971) studied 85 exemplary student artists, architects, and engineers in order to acquire more information on the influence of different perceptual styles on responses to inkblots. As part of their literature review they referred to work by D.W. MacKinnon on creativity within those particular fields of endeavor. Citing MacKinnon's work they have written that

> his findings, while supporting his general view of creativity as involving originality, adaptiveness, and realization, indicated that creative striving and production require different characteristics and processes in different fields of endeavor. In particular, he pointed out that, in the physical sciences and in engineering, the individual must adhere closely to the structural and functional demands of reality, while contributing very little of his own personal style to the process (p. 433).

Further questions that must arise are: How much of a person's own style, cognitive, perceptual, and/or learning style, mediates the visual event? and How do those styles interact with specific modes of pictorial information during the visual event?

Hortin (1982-83) believes that the visual event is comprised of three levels. The first level is the "before-the-event" level. This level presumes that prior experiences, schemata, and long-term memory are brought to the visual event, and affects our viewing of it. The second level is the "straightforward experience". This is when we experience the visual event and become involved with it - the experience is made real. Finally, the third level occurs when we think and reflect upon the visual event.

Implicit in this model are two levels of understanding: the surface (descriptive) level and the deeper (understanding) level.

> Both levels are needed to comprehend and appreciate images and each level affects the other. A person's perspective or point of view is important part of the visual event, and perspective depends on the background of the person, the actual experience of the visual event in terms of amount of involvement, sensations, effects, etc., and reflections afterward. Structure and elements also influence and are influenced by background, the actual experience and the reflection upon the experience (p. 236).

Perception is therefore a constructive event. Moreover, perception involves active processing by the perceiver in response to the stimulus. The description of the event as prior experience, the visual event experience, and the reflective experience mean that the person is actively involved in constructing a new understanding of the visual event. Since our previous understanding of cognitive style research involves the mediation of the visual event by individual modes of field dependency, all three phases therefore must be related to this mediation.

How actively involved is an engineer in a visual event? What constraints affect their perception of the visual event? Hortin's work indicated implicitly that engineers and technicians must be as actively involved with the visual event and the mode of visual presentation as any other human being. Hortin also agreed with Holtzman and Schwartz that the structures, elements, and functional demands of their labors must affect their labor production, and in part therefore, clarify their own personal style.

From the study by Holtzman and Swartz (1971), they further identified that the engineer (males in their study) due to "his preoccupation with the world of mechanical reality would probably also result in fewer precepts involving human beings than in the case of the artist or architect" (p. 434). Furthermore, "the Engineer group showed the most ability to inhibit impulse responses" (p. 443). Both the finding of fewer test responses involving human precepts and the structured, analytical style of responses of the engineering subjects were congruent with the field-independent cognitive style proposed by Witkin as identifying engineers and technical personnel.

F. M. Dwyer (1970) in her early work on the pictorial effects of b&w visual illustrations on the learning of technical material by university students noted that "the use of visual illustrations is not necessary to complement oral instruction designed to promote learning objectives" (p. 38). Moreover, "the realistic detail within the visual illustrations used to complement the oral instructions may have the net effect of distracting the attention of the students from the essential learning cues, thereby interfering with rather than facilitating student achievement" (p. 38).

Another noteworthy point from Dwyer's work is the conclusion that larger visuals do not necessarily facilitate learning. In fact, the learning facilitated by the 22-inch b&w television monitor was superior to the learning facilitated by a 6 by 4 foot rear project screen. "The success of the instruction on the 22-inch monitors may be explained by the fact that the visuals presented more clearly the information needed by students to achieve specific objectives" (p. 40).

As well as the deterioration of picture quality on the larger screens, Dwyer indicated that the student's learning may have been made more difficult by the increased size of viewing area. This required the students to spend more time searching for relevant information. "Apparently the ability to be able to perceive clearly the relevant instructional characteristics in visuals is prerequisite for visual learning" (p. 46).

A great deal of research has been completed since F.M. Dwyer's early studies and "there is some evidence that representational pictures can be effective in facilitating adult learning. Pictures have aided recall, although not necessarily for material that is highly abstract or complex" (Alesandrini, 1984, p. 68). On the other hand, children being read prose benefited regardless of subject area, complexity, or individual differences. Carrier, Joseph, Krey, and LaCroix (1983) noted from the work of other researchers that

> after reviewing studies comparing pictures versus no picture Levin and Lesgold (1978) concluded that for orally presented prose, pictures increase learning for children when the pictorial material overlaps story content. This superiority for pictures held up across different subject areas, degrees of complexity of material, and age and ability levels of the subjects (p. 154).

Carrier et al. (1983) also hypothesized that since pictures were very powerful mediators in the facilitation of learning, pictures (versus imaging) shown prior to, during, and after story-telling would be of greater benefit to field-dependent children than to field-independent children. This was not the case. "The expected interaction between cognitive style and treatment did not occur. Field independent children outperformed field dependent children regardless of treatment" (p. 159).

D.M. Moore has two studies which also produced conflicting results regarding diagrammatic effects, order presentation, and cognitive style. In his 1985 study, it was found, contrary to his "holistic" hypothesis, that field-dependent subjects performed better on visual locations tasks when composite pictures were presented in a linear "build-up" manner versus a multiple image "complete" presentation manner. Moreover, further undoing the field dependence hypothesis, field-independents scored higher on the multiple image treatment than on the linear presentation treatment.

In his other study with three modes of pictorial representation (painting, photographs, line drawings), D.M. Moore (1985) found that there were no statistically significant results in visual information processing (content recall) by field-dependents or field-independents. Contrary to the research by F.M. Dwyer, results of Moore's study indicated that the 132 undergraduate subjects least preferred line drawings in the recall of content information. Interestingly enough though, the one-half sized paintings had the highest mean score, the one-quarter sized photographs had the second highest mean score,while the full sized line drawings had the third highest mean score. Although there was no discussion as to the complexity of the information portrayed in these pictorial modes, all pictures were placed on 35mm slides and shown on a 25-inch b&w monitor. It may be assumed that the photographs were the most complex and therefore were processed more easily on a quarter-frame slide, whereas the line drawings were the least complex and could be processed more easily using a full-frame slide.

J. Hartley (1986) has noted that "there has been little research on the positioning of illustrative materials in relation to text" (p. 328). Illustrative materials are defined as tables, graphs, and diagrams. He has written, "I found in one of my unpublished studies that 19 out of 20 students preferred a four page version of a technical text from Bell Laboratories when the illustrations in the text were repositioned so that they fell much closer to their textual reference" (pp. 328-329).

In citing another work, Hartley noted that "Whalley and Fleming (1975) found that electronics students spent more time inspecting diagrams in an article on electronics when the diagrams immediately followed the sentences which referred to them than they did when the diagrams were positioned to balance the page" (p. 329). Moreover, in another study on how to focus attention on illustrative material, "Brody (1982) reported that Gombrich deemed captions to be one of the most critical variables in understanding picture" (p. 329).

K.L. Alesandrini (1984) in research on pictures and adult learning studied the effects on learning of three types of pictures: representational, analogical, and arbitrary pictures. Alesandrini noted that numerous studies "suggest that it may be difficult to devise representational visuals for certain topics but that this type of picture can facilitate adult learning" (p. 65).

Representational pictures are defined as pictures that share a physical resemblance with the thing or concept that the picture stands for. As pictorial information, icons can be considered "representational pictures". On the other hand, as pictorial information, block diagrams can be considered "arbitrary pictures". Arbitrary pictures are defined as pictures that represent, but do not look like the things that they represent. Arbitrary pictures in visuals are highly schematicized, and are related logically or conceptually.

Can very concrete, detailed visuals composed of icons assist the engineer and technician process visual information? If not, can the highly schematicized arbitrary picture assist? Furthermore, since "the variable of color, in particular, adds to the complexity of a picture" (Alesandrini, 1984, p. 66), will colored icons and/or colored block diagrams aid or hinder the learning process of engineers and technicians due to their high complexity? Only further research will help answer these questions.

Educational Implications of Field Dependence

The research on the educational implications of cognitive and learning styles has been focused in the realm of the younger student and the college undergraduate. This research has been important in the study of vocational preference, choice of major, and shift in major. Unfortunately, even in these studies there has been little information concerning vocational training, business and industry, and the adult learner. "The extent of awareness and application of learning styles research to vocational education is probably less than that in other educational programs" (Knaak, 1983, p. 23).

It is important to emphasize the need for more research into cognitive and learning styles, training in business and industry, and the adult learner. Training intervention or treatments for the adult learner will be successful only when understood both in the context of adult learning theory and classroom implementation. This research is needed because "the application of treatments through learning styles theory reduces the guesswork involved in the process and heightens students' awareness of their strengths and weakness" (Knaak, 1983, p. 18). Until now, much of the training in business and industry has not only been reactive (i.e., band-aid approaches to filling training "gaps"), but also guesswork; and therefore, often very inefficient and ineffective in meeting the needs of the student.

Educational Implications for Students

It has been identified that field-dependent students, children and adults, are more attuned to their social context, both to the environment and to its people. It follows that they also attend to learning and remembering material that is more socially oriented. They are better at picking up social cues, and are more selectively attentive to and superior in recognizing faces. "The implications of these findings for the classroom are apparent. Because of their social orientation relatively field-dependent children are apt to be particularly adept in learning and remembering materials that have social content. To the extent that the inferiority of field-independent children with such material is a function of lack of attention, rather than a lack of ability, their performance can easily be made equivalent to that of field-dependent children by bringing social material to focal attention..." (Witkin et al., 1977, p. 19).

The important point to remember is that although a student's cognitive style is relatively stable, the student's behavior can be adapted. It is known through research that the "more independent students favor domains in which analytical skills are called for, whereas field dependent students avoid such domains. Examples of analytical areas are the physical and biological sciences, mathematics, engineering, and technical and mechanical activities" (Witkin, 1976, p. 50).

Generally, engineers and technicians choose a vocational field that is congruent with their cognitive style. If their cognitive style is most often field-independent, as identified in certain research (Barrett & Thornton, 1967), how can business and industry benefit by their engineers and technicians adapting their behavior to be more field-dependent?

Much of the training and re-training for engineers and technicians is of a technical nature. This type of training assists engineers and technicians in their day-to-day work, which normally deals with responsiblities in job domains such as manufacturing, and research and development. For many engineers and technicians their work responsibilities must be complemented through the enhancement of their ability to market and sell the fruits of their labors (e.g., machinery, tools, instruments, and processes). Without the ability to interface with other human beings, with a focus on customer service, wealth cannot be generated for themselves or their company. Therefore, the development of field-dependent behaviors through taking courses such as marketing courses is deemed to be advantageous in both a personal and business sense.

Not all engineers and technicians are field-independent. There is a small proportion of engineers that are field-dependent. For them, the use of appropriate learning reinforcement techniques may be important. Although the majority of engineers and technicians are field-independent and learn well under conditions of intrinsic motivation, their field-dependent peers require from the instructor more positive reinforcement and motivation in order to succeed. "Whether used conciously or unconciously, reinforcement is one of the handiest tools in the teacher's armamentarium of devices for perpetuating some student behaviors and eliminating others" (Witkin et al., 1977, p. 20). Any difference in achievement between the well motivated field-dependent student and the field-independent student should be eliminated by intelligently applied reinforcement techniques. "The evidence suggests, as expected, the field-independent persons tend to learn more than field-dependent persons under conditions of intrinsic motivation. However, this difference disappears when external rewards for learning are introduced, regardless of whether the rewards are material in nature or in the form of praise" (p. 20).

It is also clear that field-dependent engineers and technicians may need assistance in learning from technical training courseware. Much of the courseware in business and industry is poorly designed and developed. "Frequently in learning, the material to be learned lacks clear inherent structure, creating the requirement that the learner himself provide organization as an aid to learning. Field-dependent persons are likely to have greater difficulty in learning such material compared to field-independent persons who are more likely themselves to provide the mediating structural rules that are needed to facilitate learning" (Witkin et al., 1977, p. 21).

One suggestion on how to structure learning materials in order to assist the field-dependent learner comes from studies in programmed instruction. Learning sequences should consist of "small-step" learning blocks with clear examples, time for discussion, and frequent feedback. (The assumption here is that the technical courseware designer understands the significance of these concepts.) Furthermore, it is important that structured exercises, graphics with relevant cues, problem-solving cases, and hands-on work identify the technical training approach for field-dependent engineers and technicians. Field-independent types seem to learn just as well in this type of training environment as in a less structured training environment. We know that "field-independent persons are more likely to use mediators, of their own design, in dealing with a learning task, whereas field-dependent persons are more likely to rely on the characteristics of the learning task itself" (Witkin et al., 1977, p. 23).

"Explicit training efforts have most often been in the direction of making individuals more field independent, and speculations about classroom interventions have tended to stress the positive educational exploitation of existent analytic capabilities. Not much is said about the positive qualities of field-dependent individuals" (Kogan, 1971, p. 252). Since field dependence theory holds that this bi-polar cognitive style is value free (i.e., neither a field-dependent score nor a field-independent score [as identified by the GEFT] is "better" than the other), technical training personnel could assist in the development of adaptive behavior and learning. Such training would assist engineering and technical students in developing more balanced social behavior patterns, and more global thinking patterns.

"Witkin's analytic-global dimension would appear to be ideally suited for research on the interaction between variables of cognitive style and instructional treatment. Both ends of Witkin's dimension have adaptive properties, though of a distinctly different kind, and it is feasible that educational programs could be devised to profit each of the polar types" (Kogan, 1971, p. 253).

Educational Implications for Teachers/Instructors

Research into the role of teachers and cognitive styles has accumulated a growing database of information. The teacher who has a more social orientation (i.e., field-dependent orientation) is likely to promote interactivity in the classroom, and share the responsibility of teaching with the students. On the other hand, the teacher who has a more impersonal orientation (i.e., field-independent orientation) is more likely to have a structured curriculum, and retain complete control of the teaching situation.

If field dependence as a cognitive style is relatively stable within each person, as the research seems to indicate, then recent studies would indicate that teachers of adults in the engineering field will be predominantly field-independent. A study by Frank (1986) found that "cognitive style is related to choice of area of specialization among teacher education majors..." (p. 21). He found that students specializing in mathematics and natural sciences were more field-independent than those specializing in the social sciences and humanities.

These results concur with Witkin's findings on educational-vocational interest. "It has been found repeatedly that the responses of more field-independent people to standard interest inventories are consistent with those of people in mathematics and science domains - as, for example, mathematician, physicist, chemist, biologist, architect, engineer..." (Witkin et al., 1977, p. 40). Furthermore, "in some studies field-independent persons have also shown interest in the teaching of mathematics-science, industrial-arts and vocational-agricultural subjects" (p. 40).

The teaching of engineering courses at universities is generally pursued by engineers; the teaching of technical courses (e.g., radio-electronics) at community colleges is generally pursued by graduates of those colleges; and in the case of technical training in business and industry, the teaching staff is predominantly composed of men (engineers and technicians) who have moved into training from the manufacturing and research and development ranks of that same corporation or company. In all three of these teaching and training scenerios, the predominant cognitive style of the teacher can be hypothesized to be the field-independent style. Witkin (1976) observed that "engineering students whose interests were mainly restricted to the physical sciences were more field independent than were those whose interests extended into domains..." (p. 51). Further research is required in this area of study.

Since as a general principle "relatively field-independent persons, taken as a group, are likely to show interest in domains where their cognitive skill - competence in articulation or in analysis and structuring - are called for and where relations with people are not particularly involved" (Witkin et al., 1977, p. 40), is it possible that teachers of engineers and technicians are out of their element? That is, since teaching is often viewed as a field-dependent activity - socially oriented, interactive, supportive - will the field-independent cognitive style of the engineer-trainer be incongruent with the field-dependent nature of training?

Field-independent teachers generally employ lecture style and discovery style methods in their classroom teaching. "Both lecture and discovery approaches reserve to the teacher much of the organization of the learning situation, either through facilitating and guiding the student or through providing information" (Witkin et al., 1977, p. 28). The field-independent teacher also uses questioning as an instructional tool versus using it to confirm that which the student has learned. This kind of questioning technique used by the more field-independent teacher may be viewed as the main approach in an attempt to use the discovery teaching method within the context of instruction.

Approaches to control of students in the classroom, setting of performance standards, and reinforcement techniques differ between field-independent teachers and field-dependent teachers. Field-independent teachers need to control the ebb and flow of interactivity in the classroom thereby assuming sole responsibility of organizing and guiding student learning. They also set standards of performance with little or no input from students. Furthermore, field-independent teachers feel that informing the student when a response is incorrect is effective in enhancing student learning.

There seems little doubt that the teacher of engineering and technical students, whether a field-independent or field-dependent, has most often been effective and successful in fulfilling their mandate. "The differences between field-dependent and field-independent teachers seem to lie rather in their approach to the teaching situation" (Witkin et al., 1977, p. 31). It is this approach that has concerned some teacher-researchers.

Ablin and Flammer (1974) have commented on the lecture method of instruction used in engineering education. "The lecture method of instruction (LMI) is in particular need of attention..." (p. 404). It has an obsession with dispensing content; it is content referenced and not performance referenced; tests are almost exclusively used for grading; it requires only passive involvement; and it doesn't take into account that "individual students have different learning problems and different strategies of learning which need to be handled individually..." (p. 405).

Staiger (1984) noted in his work that the process of problem solving and the different approaches to the evaluation of the process of problem solving is of great importance to engineering students and technicians.

> The process of problem solving, so important in engineering, requires what has been called divergent and convergent production. Divergent production is the generation of logical imperatives. While some methods of evaluating learning require students to use both of these mental processes, convergent production is usually overemphasized - that is, the correct answer is scored rather than the process or methodology (pp. 653-654).

Morrison's study (1985) tied cognitive style (focusing and scanning) to the process of student problem solving in his study on fault diagnosis performance by mechanics instructed to find faults in units of a network. The mechanics manner of performance as dictated by their cognitive style, and concerns over normative evaluation were brought into question. Morrison noted that "cognitive style measures are said to differ from ability measures in that they are concerned with the qualitative aspects of performance, i.e., the route to solutions rather than the correctness of the solution" (p. 133).

Given the apparent concerns over the differences in the approach to the teaching of students with differing cognitive styles, specifically engineering students and technicians, and the perceived need to alter some of these approaches, what has been the effect on meeting the learning needs of the students?

Witkin et al. (1977) found that even with contrasting styles in teachers, these differences do not mean that there are similar differences in teaching competence. Taking student achievement as the product of the teacher's teaching efforts, "the differences between field-independent and field-dependent teachers seem to lie rather in their approach to the teaching situation..." (p. 31).

The question that arises is whether teachers can adapt teaching approaches, other than those fostered by cognitive styles, in order to meet the needs of a particular student. Frank (1986) extends this adaptive concern for teachers to students. "A more basic issue may be whether the heterogeneity of students' and subsequently teachers' cognitive style within an area of specialization can (or should) be extended" (p. 21).

Adaptation to different teaching and learning needs might be facilitated through the sensitizing of both teacher and student to their individual cognitive styles. "... by sensitizing teachers to the implications of their own cognitive styles and the styles of their students for the teaching-learning process, we may increase the adaptability of teachers, so they become more diversified in the teaching approaches they use" (Witkin et al., 1977, p. 32). Bertini (1986) also noted that "the sensitizing of the teacher, and perhaps the student, to the complexity of reciprocal interaction, and equipping them with some specific tools for handling those interactions indeed seems an important step toward achieving the goal of increased teacher effectiveness" (p. 104).

Educational Implications for Student-Teacher Interaction

"Certainly, people in education are well aware that teaching effectiveness is a result of a complex interaction among teacher, student and subject to be taught" (Bertini, 1986, p. 94). Research has shown that the match or mismatch of student cognitive style to that of the teacher is important in how teachers perceive the abilities of their students. In fact, it has been shown that there have been "matching effects on objective test performance and on teachers' and students' subjective ratings of each other" (p. 97).

Since shared personality characteristics, shared interests, and similarity in modes of communication may be the basis for greater interpersonal attraction between students and teachers of similar cognitive style, it may be appropriate to have them teach and study in the same classroom. "On the surface, it would appear beneficial to group students homogeneously in terms of particular stylistic dimensions, and to assign a teacher and/or an instructional format to that group in order to optimize learning and performance" (Kogan, 1971, p. 291).

Engineers and technicians, whether studying in a formal school setting, or studying at a training center in business and industry are generally well matched (i.e., in cognitive style) within their group, and with the teacher.

In the case, though, where there is a mismatch, there are two situational variables that moderate the effects of the mismatch. The first is that field-independent male teachers tend to "reject" (i.e., like less) male students. Therefore, for the few female engineers and technicians who are field-dependent, their learning efforts in training classrooms should be viewed favorably. "It seems that, whereas field-dependent teachers tend to reject students of the opposite sex, field-independent teachers tend to reject students of the same sex" (Bieri, Bradburn & Galinsky, 1958, p. 101). The second situational variable that may modify cognitive style match-mismatch effects is course curriculum. "In areas where good student performance requires highly specialized skills, the availability of these skills may overwhelm cognitive-style match-mismatch effects" (Witkin et al., 1977, p. 37).

Summary

As noted, there are at least nineteen conceptualizations of cognitive style. They are conceived of in terms of actual structures within the cognitive system, as models of information processing, and as sundry other conceptualizations including srategies of learning and knowledge.

The history of research into cognitive style identifies H.A. Witkin as the father of such research, specifically research surrounding the cognitive style of field dependence. His research started with a test of perception, the Rod-and-Frame Test, using individual subjects in laboratory settings. The research has since been expanded using a timed-test, the Group Embedded Figures Test, which is used with larger groups and is not restricted to laboratory settings.

Field dependence, as a cognitive style, has evolved from a simple perceptual based construct through to a high-level construct called differentiation which is identified by a greater specialization of function, and self-nonself segregation. As part of this high-level construct is the articulated-global dimension. This dimension defines a person in terms of both an ability to be more or less data selective, and an ability to restructure a stimulus field based on internal frames of reference.

Four mediating factors are discussed with regards to field dependence and visual information processing: memory and recall, color and b&w effects, gender effects, and pictorial effects.

Field independents are better able to focus their attention, encode visual information more effectively, and structure visual information more efficiently than field dependents. They are able to do this through their ability to separate themselves from the activity of viewing the stimulus field (self-nonself segregation).

The use and effectiveness of color in visuals continues to stir debate. One researcher has noted that color affects the emotions and physiology of the viewer - sometimes negatively. Many researchers, though, note that color motivates and stimulates the viewer. At the same time color does make visuals more complex in terms of visual information processing. On the other hand, simple black and white line drawings, rather than highly detailed shaded drawings, seem to assist in the encoding and retrieval of visual information.

Using the GEFT, initial research by Witkin et al. (1977) found that males were more field-independent than females. This study and other studies have discussed this finding in terms of sex-role assignment, cultural differences, and biological differences. It seems, though, that the field dependence cognitive style is adaptive. Men and women can learn to employ strategies that will allow them to be more field-dependent or field-independent depending on the information processing demands.

Finally, the educational implications of cognitive style research affect both the student-trainee and the educator-trainer. A better understanding of the mediating effect of cognitive style on learning by the student-trainee will assist them in employing appropriate learning strategies for specific courses. At the same time, the educator-trainer will be able to employ more appropriate, and therefore, effective classroom and curriculum design methods for specific courses, and the students that attend them.

CHAPTER THREE

Research Design

Introduction

This project was comprised of two-stages. First, the Group Embedded Figures Test (GEFT) was used to identify the cognitive style preference of engineers and technicians (male and female). Second, the experimenter's test was used to gather recall scores through multiple-choice questions while the subjects viewed block mode and icon mode graphics.

Once the data were gathered, analyses were performed using the University of Ottawa mainframe computer and IBM AT compatibles. Analysis of variance, regression tests, and t-tests were used to develop statistical inferences for the four project hypotheses.

Subjects

Engineers and technicians taking classes at Northern Telecom's technical training facility in Ottawa were the subjects (N=62) for this experiment. There were 50 male engineers and technicians, and 12 female engineers and technicians. One of the male subjects showed perceptual problems on the GEFT, and therefore, his test results were not included in the project results.

The subjects were asked to take part in the experiment, and were given the option to decline if they so wished. Request for their assistance was based on a need to better the quality of technical training courseware. Anonymity was assured unless the subject requested information on their cognitive style and/or experimenter test scores.

Apparatus

The experiment's sessions were run in LAB2 and LAB3 at the training center. Since the experiment used computer-based projected graphics, the computer hardware, screen location, and timing of graphics were very important.

Presentation hardware included an Electrohome ECP 2000 color video projection unit (ceiling mounted). It was interfaced to a Northern Telecom AOS microcomputer (an IBM AT compatible) with a high-resolution color monitor.

Graphics software for the experiment included MicroSoft's Show Partner. This software allowed for a pallet of sixteen (16) colors, and consistent timing of projected graphics.

The experimenter's graphics were initially created in GEM DRAW (Digital Research), captured by Show Partner, and then colored as required.

Three shows for the experiment were developed from a random selection of sixteen graphics. These shows were placed on the thirty (30) megabyte drive of the microcomputer.

Projection was to a five (5) foot by ten (10) foot glass bead screen (LUMA 2 by Draper) at the front of the room. Although easily viewed by all subjects wherever they sat, the image focus at the edges of the screen was fuzzy. (This is due to the physics of light projected from the convex lens of the red-green-blue [RGB] projection unit to the flat glass bead screen.)

Instrumentation

Instrumentation for the experiment consisted of two components: the Group Embedded Figures Test (GEFT) and the experimenter's test instrument (graphics and Information/Answer Sheet).

The GEFT is a standardized test that assists in the identification of cognitive style, specifically field-dependence and field-independence. A Manual For Embedded Figures Tests reports a reliability estimate of .82 for the GEFT.

The GEFT is a speed test and consists of one introductory section and three test sections. All three test sections are timed and marked, but only the last two are used to define the subject's cognitive style. The first test section takes two minutes (seven complex figures), and the last two test sections take five minutes each (nine complex figures each).

For the experimenter's test portion, a two page Information/Answer Sheet was used. The first page of the Information/Answer Sheet included areas for completion by the subject. These areas included date, gender (male or female), and job position (engineer or technician). This page also included optional areas for subject name, department number, and signature.

As part of the Information/Answer Sheet, there was also a multiple-choice answer sheet. It consisted of twenty-eight (28) multiple-choice (A,B,C,D) answers from which a correct answer was to be chosen and circled by the subject. The answers were physically grouped into a set of two for the two preview questions (at the top of the answer sheet), and into three sets of four for the test questions (positioned across the page). All A,B,C,D answers (two columns) for each graphic were headed with Graphic 0a... Graphic 0b ...Graphic 1...Graphic2 ...Graphic 12.

The experimenter's test instrument involved a presentation (SHOW1 or SHOW2) was composed of three parts: an instruction text screen (45 seconds) and a referent text screen titled ISDN (45 seconds); two preview graphics screens preceded by an audible beep (25 seconds each) each with two multiple choice questions (15 seconds each); and twelve (12) test graphics each preceded by an audible beep, by a text banner (3 seconds) and followed by two multiple choice questions (total for each graphic, banner screen, and two multiple choice questions - 43 seconds). Total time for the experiment's presentation was 11 minutes and 56 seconds.

In order to put together the twelve test graphics for the SHOWs and present a balanced set for each mode of representation, four (4) graphics screens for ISDN networks were developed for each mode. From each of these modes three (3) graphics screens were randomly chosen. Then the order of graphics for each SHOW was randomly chosen. For each graphics screen, two multiple choice questions were also developed. The order of multiple choice questions (there were two for each graphic) for SHOW1 was A,B for the complete show; for SHOW2 was B,A for the complete show.

Due to the constraints of the computer software, the presentation order of graphics screens was fixed for the two SHOWs. This constraint facilitated the marking of subject's answer sheets.

Design

The experiment consisted of two stages. The first stage was a standardized test, the Group Embedded Figures Test (GEFT). The second stage was the experimenter's test.

For the experimenter's test, there were two treatment groups: 1) male engineers/technicians, and 2) female engineers/technicians.

The dependent variable was the recall test scores. The independent variables were each of the four modes of representation: 1) b&w block graphics, 2) b&w icon graphics, 3) color block graphics, and 4) color icon graphics.

Procedure

Prior to beginning each session of the experiment, a random choice of show/presentation was made: SHOW1 or SHOW2. The computer and SHOW PARTNER software were activated and checked prior to subject arrival.

Upon subject arrival in the presentation room, each was given a large white envelope holding the GEFT and experimenter's Information/Answer Sheet. Subjects were requested not to open the envelope until advised to do so. Two sharpened pencils were also given to each subject.

Once all subjects were seated, they were asked to remove the smaller of the two documents, the GEFT, from the envelope. They were asked to complete the front page without name, unless they wished the results of the experiment. The instructions in A Manual For Embedded Figures Tests were then used to direct the students in the completion of the GEFT. When the GEFT was completed by all subjects, they were requested to place the test back in their large white envelope.

At that point, the subjects were directed to take the Information/Answer Sheet from the white envelope. Once again the front page was completed without name, unless the subject requested the results of the experiment. Directions for the completion of the answer portion of the Information/Answer Sheet were given following the text of the standardized direction sheet developed by the experimenter.

For each session of the experiment, there followed one of two shows, SHOW1 or SHOW2, with each subject viewing the graphics and answering the multiple choice questions.

Upon completion of the experimenter's test, the subjects were asked to return the Information/Answer Sheet to the white envelope.

Scoring & Analysis

The experimenter marked parts two and three of the GEFT using the standard score key provided for the test. Subjects were assigned to field-dependent and field-independent conditions via a median split on the scores within each sex (male = 16.00 and female = 14.00). A GEFT score of the median value or higher was scored as field-independent; if lower, field-dependent. The experimenter defined this division of two groups since the GEFT manual gives no grouping guidelines. (Other studies have followed this approach [Reardon, Jolly, McKinney, & Forducey, 1982].) A correct score marked out of eighteen from sections two and three was computed for each subject.

For the experimenter's test, the preview multiple-choice questions were not marked. The following sets of twelve test questions were marked for accuracy of recall using an answer key developed by the experimenter. A subject's score consisted of five sets of correct answers to the multiple choice questions; a b&w block correct score, a b&w icon correct score, a color block correct score, a color icon correct score, and a total correct score consisting of all correct answers.

Analysis of the scores from the two stages of the experiment was completed using the SPSS-X statistical package on the University of Ottawa mainframe computer. Analysis of variance, regression tests, and t-tests were used to analyze the data.

CHAPTER FOUR

Research Results

Introduction

The research results in this project help to clarify the significance of gender in the perceptual dimension of field-dependence and how engineers and technicians process visual information. Furthermore, the results identify the importance of mode of representation (i.e., b&w block, color block, b&w icon, and color icon) in facilitating the recall of information from complex graphics.

Findings of the Hypotheses

Hypothesis #1

Based on the Group Embedded Figures Test, engineers and technicians will be found significantly more field-independent than the population identified in the A Manual for the Embedded Figures Tests (M =12.0 [males]and M = 10.8 [females]).

The normative means found in the Embedded Figures Manual were 12.0 for males and 10.8 for females. Witkin, Oltman, Raskin, and Karp (1971) noted that these norms "are based on men and women college students from an eastern liberal arts college.... and are strictly applicable only to individuals coming from populations similar to the group from which the norms were obtained" (pp. 28-29). In another study, Reardon et al. (1982) had comparable means for males (12.42) and for females (10.77).

Since the means of both the Witkin et al. (1971) study and the study of Reardon et al. (1982) were similar (and the warning of Witkin et al. [1971] notwithstanding), the means in the Witkin et al. study were used in this project's analyses.

Using an independent t-test ($t = .5295$, $df = [1,49]$, $p < .05$), male engineers and technicians were not found to be significantly more field-independent than the male population used in the Witkin et al. (1971) study. Moreover, using the same independent t-test ($t = .3772$, $df = [1,11]$, $p < .05$), female engineers and technicians were also not found significantly more field-independent than the female population in Witkin et al. study. Therefore Hypothesis #1 was rejected.

The distribution of the GEFT scores for the male engineers and technicians (N = 50) shows a skewing towards the field-independence pole (see Figure 1). Descriptive statistics for the male subject group is found in Table 1.

Figure 1 - Histogram of GEFT Scores (males)

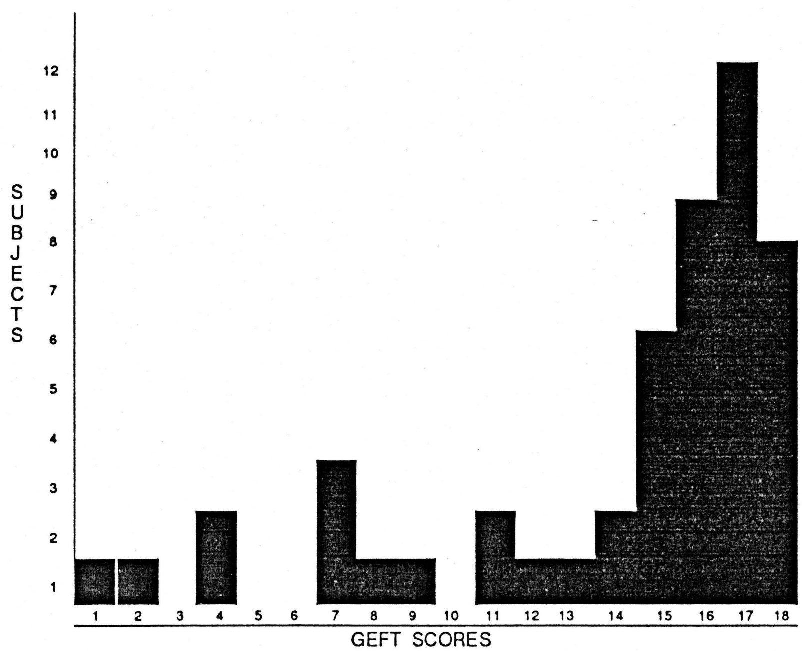

Table 1: Descriptive Statistics - Male Engineers & Technicians

N	= 50	St. Dev	= 4.580
Mean	= 14.140	S.E.M	= 0.648
Median	= 16.000	Sum	= 707.000
Minimum	= 1.000	Variance	= 20.980
Maximum	= 18.000		

The distribution of the GEFT scores for the female engineers and technicians shows a bimodal distribution (see Figure 2). It should be remembered that the sample size (N = 12) is small. Descriptive statistics for the female subject group is found in Table 2.

Figure 2 - Histogram of GEFT Scores (females)

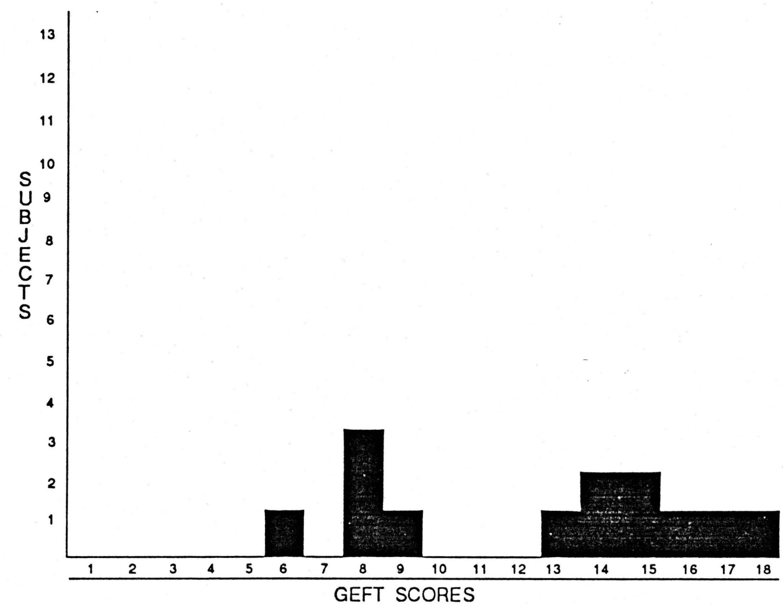

Table 2: Descriptive Statistics - Female Engineers and Technicians

N	= 12	St. Dev.	= 4.032
Mean	= 12.385	S.E.M.	= 1.118
Median	= 14.000	Sum	= 161.000
Minimum	= 6.000	Variance	= 16.256
Maximum	= 18.000		

The distribution of the GEFT scores for all engineers and technicians (N = 62) also shows a skewed distribution towards the field-independence pole (see Figure 3). Descriptive statistics for the complete subject group is found in Table 3.

Figure 3 - Histogram of GEFT Scores (all subjects)

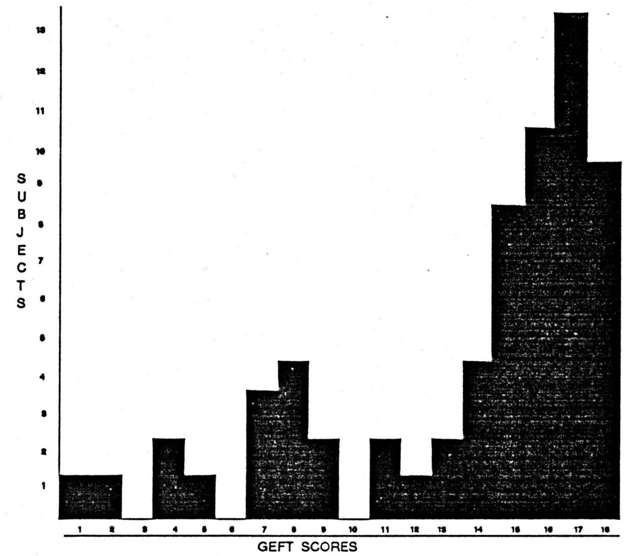

Table 3: Descriptive Statistics for All Subjects

N	= 62	St. Dev.	= 4.499
Mean	= 13.778	S.E.M.	= 0.567
Median	= 16.000	Sum	= 868.000
Minimum	= 1.000	Variance	= 20.240
Maximum	= 18.000		

Hypothesis #2

On a test of short term recall (multiple-choice questions) administered after viewing a series of complex graphics, there will be no significant difference in the recall of visual information between male and female engineers and technicians.

A 2 X 4 ANOVA (gender by modes of representation) using repeated measures was performed with the project data. This preliminary test showed no main effects for sex (Table 4), but showed significant main effects ($F = 17.61$, df = [1,3], $p < .000$) for mode of representation (see Figure 4). There was also no interaction between sex and mode. Therefore Hypothesis #2 was accepted.

Table 4: Analysis of Variance of the Effects of Gender on the Recall of Visual Information

Source of Variation	SS	DF	MS	F	Sig. of F
Between Subjects					
WITHIN CELLS	172.43	60	2.83		
SEX	0.00	1	00	.00	.971
Within Subjects					
WITHIN CELLS	207.46	183	1.13		
MODE	59.91	3	19.97	17.61	.000
SEX BY MODE	1.18	3	.39	.35	.792

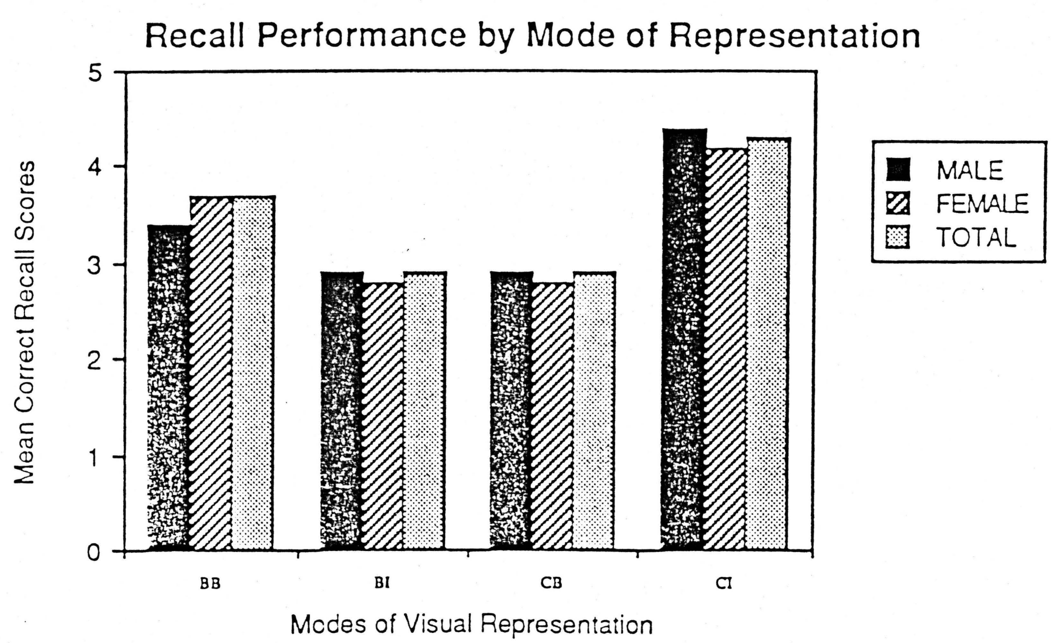

Figure 4

Cell means and standard deviations of recall of visual information by gender are found in Table 5. There were no significant mean differences by gender (p. > .05).

Table 5: Cell Means & Standard Deviations of Recall of Visual Information by Gender

Variable	FACTOR	Mean	Std. Dev.	N
b&w block	MALE	3.400	1.229	50
	FEMALE	3.692	1.327	12
b&w icon	MALE	2.860	1.370	50
	FEMALE	2.846	1.725	12
color block	MALE	3.880	1.003	50
	FEMALE	2.769	1.116	12
color icon	MALE	4.360	1.306	50
	FEMALE	4.231	0.725	12

Hypothesis #3

On a test of short-term recall (multiple-choice questions) administered after viewing a series of complex graphics, engineers and technicians will be able to recall more information from b&w block mode graphics than b&w icon mode graphics.

Using a correlated t-test (see Table 6) and collapsing the male and female data, significant main effects for the b&w mode of representation were found. As predicted b&w block mode graphics produced significantly better recall scores than did b&w icon mode graphics ($t = 3.34$, $df = [1,61]$, $p < .001$). Hypothesis #3 was therefore accepted.

Table 6: Correlated T-Test for B&W Block vs. B&W Icon

Variable	Mean	t-value	df	2-tail prob.
BB	3.4603			
		3.34	61	.001
BI	2.8571			

Hypothesis #4

On a test of short-term recall (multiple-choice questions) administered after viewing a series of complex graphics, engineers and technicians will be able to recall more information from color block mode graphics than color icon mode graphics.

Using a correlated t-test (see Table 7) and collapsing the male and female data, there were significant main effects for the color mode of representation, but not in the direction expected. Complex color icon mode graphics produced significantly better recall scores than did color block mode graphics ($t = -8.04$, $df = [1,61]$, $p < .000$). Hypothesis #4 was therefore rejected.

Table 7: Correlated T-Test for Color Block vs. Color Icon

Variable	Mean	t-value	df	2-tail prob.
CB	2.8571			
		-8.04	61	.000
CI	4.3333			

Discussion of the Hypotheses

Engineers & Technicians - field dependence

Engineers and technicians (males and females) who took part in this project were not significantly more field-independent than the Witkin et al. (1971) subject group. For the Group Embedded Figures Test, however, their combined means (13.8), and combined median splits (16.0) were slightly higher than those identified in Witkin et al. (1971) and Reardon et al. (1982).

With trainer observation of engineers in the technical training classroom, engineers seem to be very analytical and articulated, and therefore, able to disregard competing and salient (although irrelevant) cues in stimulus fields. Perceptually, they are also able to disembed with greater ease information that is hidden in a complex stimulus field. Finally, they seem to be well-differentiated; that is, they are not overwhelmed by the external referent (e.g., complex stimulus field), and are able to use internal resources to structure the field in such a way as to be able to retrieve important information at a future time.

Engineers & Technicians - gender

Witkin's early work (Witkin et al., 1967) with field dependence identified a difference in how males and females processed visual information. Although slight, this difference was statistically significant with males being more field-independent than females.

For this project, it was felt that there would be no difference in how engineers and technicians (male and female) processed visual information. No significant main effects for gender and visual information processing, in fact, were found. This was identified using the 2 X 4 ANOVA and multiple regression tests (see Table 4 and Appendix 8).

Male and female engineers and technicians were found to process visual information equally well in conditions of short-term memory recall. It seemed that engineers of both genders are required by the nature of their profession to adapt their behavior to its visual information processing demands. Results from this project seem to verify this adaptation.

Engineers & Technicians - b&w information processing

Previous work (C.A. Dwyer, [1986]; F.M. Dwyer, [1970], [1972]; Lamberski et al., [1983]) in visual information processing and cognitive style led the experimenter to believe that b&w graphics/line diagrams assist in the encoding and retrieval of information - more so than color.

With the target population being engineers and technicians, the results of this project showed significant main effects for b&w modes of representation. First, the b&w block mode facilitated significantly better recall than the b&w icon mode (see Table 8). This may, in part be due to the engineer's and technician's familiarity with b&w block and line modes through previous viewing of schematics and network diagrams in school and on the job. Processing of this mode of visual representation may have been well-practiced prior to taking the test.

Table 8: Correlated T-Test for B&W Modes

Variable	Mean	t-value	2-tail prob.
BB	3.4603		
		3.34	.001
BI	2.8571		

B&w icon mode, on the other hand, did less to enhance recall. It had the lowest number of correct answers amongst all modes of representation (see Table 9).

Table 9: Modes of Representation Raw Scores

BB raw score	BI raw score	CB raw score	CI raw score
220	182	199	279

Given this raw data, it is not surprising that the subjects did significantly more poorly in their recall with b&w icon graphics versus color icon graphics (see Table 10).

Table 10: Correlated T-Test for B&W Icon vs. Color Icon

Variable	Mean	t-test	2-tail prob.
BI	2.8571		
		-6.70	.000
CI	4.3333		

Engineers & Technicians - color information processing

The results of this project for color information processing yielded both significant and surprising main effects. In three cases the correlated t-tests revealed test results that showed color icon graphics to be the preferred mode of representation (see Table 11).

Table 11: Correlated T-Test for Color Icon Mode vs. Other Modes

Variable	Mean	t-test	2-tail prob.
CB	2.8571		
		-8.04	.000
CI	4.3333		
BI	2.8571		
		-6.70	.000
CI	4.3333		
BB	3.4603		
		-4.70	.000
CI	4.3594		

Given research findings (F.M. Dwyer, 1972) which found that both realism and color add complexity to graphics and visuals, it was felt that the visual processing demands of such visuals might negatively affect the recall of information. This was not the case in this project.

A potentially confounding factor with this result may be that the color icon graphics were presented in the final six graphics shown to the subjects (both SHOWs). Familiarity with the material might have facilitated the recall of information for this mode of representation.

This concern is made somewhat less significant by the fact that the three color block mode graphics were found in the last seven graphics presented (all graphics were positioned through random selection). The total raw score for color block mode was only slightly higher than b&w icon mode. Moreover, b&w block mode graphics were positioned more towards the beginning of the SHOWs and the total raw score for this mode of representation was quite high.

Other Research Findings

Correlation Matrix and Strength of Relationships

A correlation matrix was constructed to test the strength of relationships among the different measures of the project. B&w block appeared to be correlated with b&w icon, color block, and color icon ($p < .05$). Field dependence and color icon also showed a significant correlation ($p < .05$) (see Table 12).

Table 12: Intercorrelations Among the Various Measures

	FD[1]	BB	BI	CB	CI	TOTAL
FD	1.00	.10	.29	.29	.39**	.37*
BB		1.00	.43**	.32*	.30*	.68**
BI			1.00	.27	.30	.71**
CB				1.00	.17	.59**
CI					1.00	.53**
TOTAL						1.00

Correlations: GENDER

FD[1]	-.1955 (field dependence)
BB	.1380
BI	.0156
CB	.0145
CI	-.0616
TOTAL	.0606

* $p < .05$

** $p < .01$

Linear Regression used with Total Recall Scores and Field Dependence

Linear regression was used to identify the predictability of total recall scores (for all four modes of representation) from the field dependence scores (see Figure 5). The correlation coefficient was weak (r = .387). Furthermore, the relationship was not significant (t = 3.250, df = [2,60], p > .2).

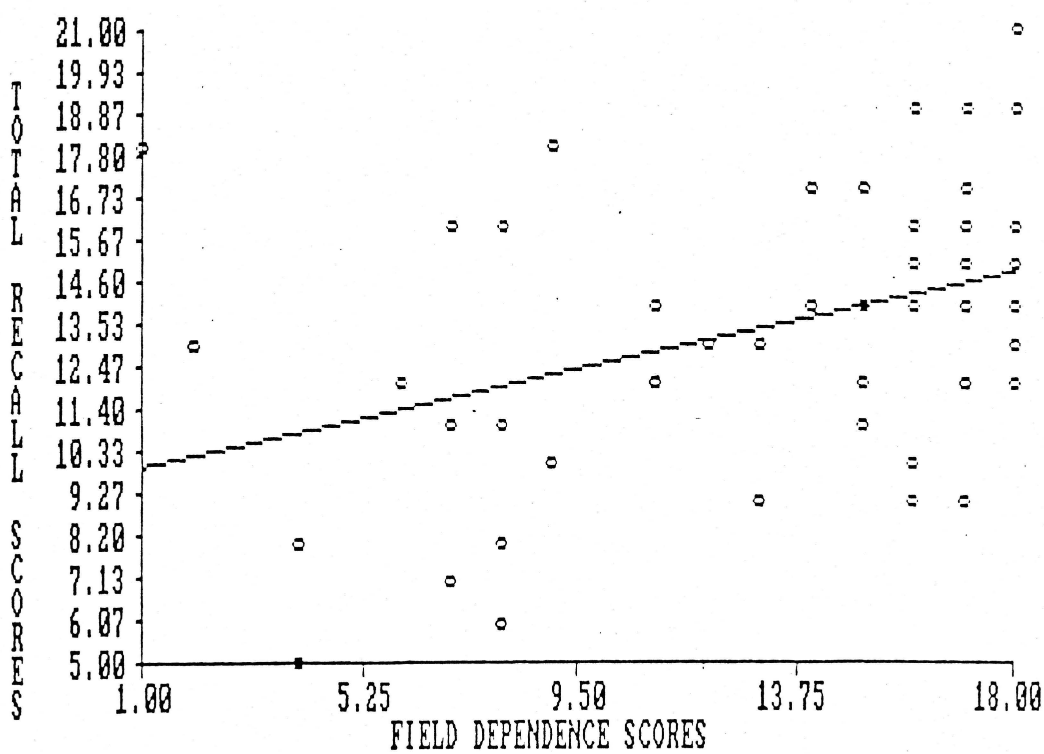

Figure 5

Multiple Regression and Project Variables

Multiple regression was then used to determine which combination of variables offered the most viable explanation of recall scores (total) on the multiple choice questions. (Multiple regression is a statistical technique which can estimate the strength of the linear relationship between a dependent (criterion) variable and a set of independent predictor variables - in this case BB, BI, CB, and CI).

A form of multiple regression called "stepwise regression" was used in this project - stepwise regression recursively constructs a prediction equation. Each independent variable was entered into the equation on the basis of the extent of the contribution of the variable by previously entered variables. The first variable was chosen on the basis of its correlation with the dependent variable and the remaining independent variables. Each of the remaining variables was then added to the first variable, and the F-statistic was used to test the significance between the R^2s obtained with the first variable and each of the remaining variables. The variable that yielded the highest F-ratio was then entered into the second step of the analysis. After obtaining the two independent variables, each of the remaining variables was added as a third variable, and the contribution of each was tested for significance. Once again, the variable that yielded the highest F-ratio was added into the third step of the analysis. This process was terminated when the addition of any more variables did not result in a significant increase in the proportion of variance explained by the variables already entered into the analysis.

Stepwise Regression on the Modes of Representation, Field Dependence, and Gender

Results of the stepwise regression analysis for the modes of representation variables are presented in Table 13. As can be seen from the table, BI accounted for the greatest explained variance ($R^2 = .50$) in the test recall scores (total). This variance was highly significant ($F = 59.67$, $df = [1,60]$, $p < .001$). In the second step BB was added, and it significantly ($F = 60.9$, $df = [2,59]$, $p < .001$) added to the explained variance ($R^2 = .67$). In the third step, CB was added, and it also significantly ($F = 68.15$, $df = [3,58]$, $p < .001$) to the explained variance ($R^2 = .78$). Finally, in the fourth and final step, CI was added, and it too significantly ($F = 92.91$, $df = [4,57]$, $p < .001$) added to the explained variance ($R^2 = .87$).

The remaining independent variables, field dependence and gender, did not contribute significantly to the explained variance. Their contribution was forced using the SPSS-X statistical package (i.e., the statistical package would not normally produce figures for non-significant contributions to total variation), and the values were very small (see Appendix 8).

Therefore, it seems that the b&w icon score predicts 50% of the total recall scores. Taken together, all of the scores for the four modes of representation account for 87% of total recall scores (see Table 13).

Table 13: Stepwise Regression using Modes of Representation Variables

Step	Independent Variable	R2	Beta	df	F
1.	BI	.4986	.7061	1,60	59.6672 ***
2.	BI	.6737	.5041	2,59	60.9018 ***
	BB		.4646		
3.	BI	.7790	.4471	3,58	68.1519 ***
	BB		.3798		
	CB		.3464		
4.	BI	.8670	.4367	4,57	92.9122 ***
	BB		.2984		
	CB		.3231		
	CI		.3120		

*** $p < .001$

<u>Summary</u>

The four hypothesis were tested using analysis of variance and t-tests. Both linear regression and multiple regression were used for further exploration of the data. Two of the hypotheses were accepted, and two were rejected using the results from the ANOVA.

Using the sample means for field dependence from the study of Witkin et al. (1971) as normative data, both male and female engineering sample populations in this project were not found significantly more field independent than the Witkin et al. sample.

Sample population means, however, were higher than both the Witkin et al. (1971) study and the Reardon et al. (1982) study.

Between subjects data, using modes of representation and mean correct recall scores, showed no significant main effects for gender. Furthermore, within subjects there was no significant interaction between modes of representation and gender. Nor was there any significant correlation. There was, however, a significant main effect for mode of representation ($p < .000$).

For modes of representation, b&w block mode graphics aided subjects in recalling significantly more visual information than did b&w icon mode graphics. At the same time, color icon mode graphics aided visual information recall significantly ($p < .001$) more so than color block mode graphics. This latter result was contrary to expectation.

The b&w block mode was significantly correlated to the other three modes of representation. The reason for this correlation was not easily explained.

The exploratory work using linear regression with total recall scores (dependent variable) and field dependence scores (independent variable) yielded no significant results. Predicting total recall scores using field dependence scores would be extremely difficult since their relationship was weak and insignificant.

There was, however, a significant correlation between field dependence and the color icon mode of representation. It may be that the more field independent subjects were able to process more effectively the more complex color icons.

Finally, exploratory work using multiple regression did, however, yield significant results for the explanation of variation in total recall scores (dependent variable) caused by the modes of representation (independent variables). B&w icon graphics explained fully 50% of the variation in total recall scores. All four modes of representation explained fully 87% of the variation, whereas neither field dependence nor gender explained any significant additions to variance (R^2).

CHAPTER FIVE

Re-Statement of the Problem

Main Features of the Method

The project has been successful in facilitating the resolution of the project's fourfold problem. The two part experiment using a standardized test, the GEFT, and the experimenter's test was congruent with the project's need to resolve its problem within the context of the engineer and technician's work and technical training environment.

The GEFT identified cognitive style preference in the subject group of engineers and technicians. Although the mean scores for the both men and women were higher than the population in Witkin et al. (1971), they were not significantly higher. With this knowledge, it was possible to take the recall scores from the experimenter's test, and use ANOVAs, regression tests, and t-tests to identify the differential influence of cognitive style and gender on the processing of visual information. Implications for the development and use of graphics and visuals in the training of engineers and technicians follow later in this chapter.

The project method has used as a subject population, a sample of engineers and technicians, that is representative of the men and women who attend training courses at Northern Telecom's Ottawa training facility. Although the total sample is adequate for the project (N = 62), the number of female subjects (N = 12) is not a strong sample size. This constraint is due to the smaller number of female engineers and technicians normally attending training courses in Ottawa.

Notable in the project method was the project context (i.e., training facilities, A.V. equipment, and graphics). The project context for the sample population was congruent with the subjects' training context and training needs, and therefore should not be a threat to the validity of the project.

Main Findings of the Study

Cognitive Style of Engineers and Technicians

Engineers and technicians in this subject group were not found to be significantly more field-independent than the population studied by Witkin et al. (1971). Means for the GEFT (M = 14.14 [males]; M = 12.38 [females]) were only moderately higher than the means in the Witkin et al. (1971) and Reardon et al. (1982) studies.

Field Dependence and Visual Information Processing

After the subjects had viewed all of the complex graphics, it was found that field dependence as a cognitive style was only weakly correlated with the total recall scores. Furthermore, it was found that only the scores from the CI test questions correlated significantly with the scores of field dependence. Since the raw total for CI graphics was the greatest of the four modes of representation, there may be a connection for this sample population of engineers and technicians between the processing of the embedded figures in the GEFT and the processing of complex CI graphics.

Gender Differences in Visual Information Processing

There was no significant differential processing of visual information related to gender. Analysis of variance between subjects found gender to be insignificant ($p > .9$) in processing all of the modes of graphic information. Furthermore, as a source of explained variation, R^2 for gender wasn't even computed in the multiple regression test. Therefore, the strength of the relationship between the recall scores of the four modes of representation and gender was very weak.

Although other research has identified a slight statistically significant difference in the processing of visual information (specifically when using the GEFT and EFT standardized tests), female engineers and technicians processed graphic information, and answered multiple choice questions based on that information in this project as well as their male counterparts.

Modes of Representation Preferences

There was a statistically significant preference for both b&w block mode graphics and color icon mode graphics. Engineers and technicians processed the visual information in a manner which presumes a familiarity with b&w block mode graphics. This implies that they had the necessary strategies to scan, encode, and retrieve effectively and efficiently that mode of visual information. Furthermore, it is presumed that the stimulus value of color and realism of icons assisted in the recall of visual information.

Explained Variation in Test Scores (Total Scores)

B&w icon scores accounted for the greatest explained variance in total recall scores. BI scores predicted 50% of total recall scores. All four modes of representation accounted for fully 87% of explained variation. Each step in the multiple regression test was significant at the .001 level. There was a strong relationship between modes of representation and total recall scores.

Summary of Main Findings

From the numerous tests run on the sample data, there seemed to be no correlation between gender and the visual information processing demands found in this project's experiment. Moreover, field dependence was significantly correlated only to CI mode graphics. Overall, field dependence in engineers and technicians did not seem to be a strong mediator in the processing of complex visual information.

Implications for the Use of Complex Visuals in Training

Generally, field-independent persons are more capable of processing complex visual information than field-dependent persons. Specifically, since engineers and technicians tend to process visual information in a field-independent manner, educators and trainers of these men and women should endeavor to facilitate their learning through the use of graphics which employ a b&w block mode style and color icon mode style.

Although engineers and technicians are capable processors of complex information, the design of graphics can not be made too complex. Just as learning objectives in a text sense are intended to facilitate learning through "mind size" portions, the use of graphics should be designed to do the same in complementing text in the development of technical training courseware. Further research is required to define "complexity" in graphics and visuals.

Based on the results of this project, the use of "older" technologies in technical training such as overhead projectors and 35 mm slides can be enhanced to include more complex b&w block mode graphics and color icons. It is well known that these training media have been used extensively for both technical training and marketing presentations. Whether the processing of visual information using these technologies has been successful in the technical training context has not been previously ascertained.

There is now reason to believe that the use in training of these older technologies can be enhanced to facilitate learning for engineers and technicians. Furthermore, with the advent in the last ten years of more advanced "newer" technologies (e.g., interactive video and computer-based training) which can display with ease very complex graphics, the facilitation of learning using these media should also be facilitated.

The design of graphics for use in student manuals must also be considered. In many instances, graphics found in training manuals have been taken "as is" from technical documentation by technical courseware designers without consideration as to its potential training effectiveness. Using either b&w block mode or color icon mode graphics should assist in making training manuals more effective.

It has been possible for some time now to include color graphics in student manuals by using graphics produced by color ink-jet printers and color plotters. These approaches have never been that convenient for large volumes of technical training material because of the high cost. Newer technologies for copying color graphics are now on the market, and the use of color icon mode graphics in technical training student manuals will hopefully be more affordable shortly .

Researcher's Conclusions Based Upon the Findings

In the engineering profession where research and design, testing, problem-solving, and implementation are very important, the training and retraining of engineers and technicians is a vital human resource development process. To assist in this process, well-designed complex graphics, including those with color icons, can be used effectively in technical training. Since b&w block mode and color icon mode graphics facilitate better recall of graphics information, they should assist in most aspects of learning by engineers and technicians.

There need be no concerns about gender differences in learning amongst engineers and technicians caused by the use of complex graphics. Female engineers and technicians are quite capable of processing complex visual information in order to learn technical information. The only concern that educators and trainers should have is that their learning objectives should not be written with a gender bias. The challenges of hi-tech learning including the processing of complex visual information can be met by all engineers and technicians given well-designed and well-researched learning objectives.

Engineers and technicians who display a field-dependent cognitive style are in most instances quite capable of adapting their behavior to be more field-independent. Learning strategies which will allow them to attend to and scan more thoroughly complex graphics should be successful. More positive reinforcement will assist in this adaptation.

On the other hand, as has been noted, it is important that field-independent engineers and technicians adapt their behavior at times to be more field-independent. Most businesses and corporations need a mixture of both styles. This is evidenced by their preference in hiring and promoting men and women who have both engineering degrees and management degrees.

Other Research Arising from this Project

There are numerous avenues of research that can be taken using this project as a platform. Three stand out from many possible choices.

1) cross-cultural studies identifying how technical students from other countries process complex visual information. This suggestion was made by a colleague in technical documentation at Northern Telecom. Northern Telecom, as Canada's only hi-tech multi-national corporation, trains many engineers and technicians from other countries. These countries include Turkey, China, and potentially Morocco, Mexico, and others. This type of study would be of great benefit to technical training personnel and to academics.

2) a study defining "complexity" in graphics. Tabachnick and Brotsky (1976) in their research into free recall and complexity of pictorial stimuli suggest that "future research involve some provision for the evaluating of complexity of the stimulus material" (p. 470). A follow-up study after this project could endeavor to answer at what level can a graphic be defined as being too complex for facilitating learning. A portable test instrument in the form of a test booklet that would include color graphics is being contemplated.

3) a study facilitating distance education using present processes, technologies, and understanding of cognitive styles. A study by Thompson and Knox (1987) found that field-independent persons, when taking distance education programs, succeeded more often than their field-dependent counterparts . Now, as newer technologies begin to mature, including ISDN, it may be possible to assist all learners in the pursuit of education and training. Third world countries might benefit most of all from such a study.

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APPENDIX 1

DIMENSIONS OF COGNITIVE STYLE

Description

Field dependent/independent	A global versus analytical way of perceiving. Entails the ability to perceive items without being influenced by the background.	Witkin et al. (1954) Witkin (1976)
Analytical/non-analytical conceptualizing	Analytical style entails differentiating attributes or qualities. Non-analytical style responses may be more relational or thematic.	Kegan et al. (1964) Messick and Kogan (1963)
Impulsivity/ reflectiveness	Impulsivity is characterized by quick responses, reflectivity by more deliberate, slower responses. The impulsive person is quicker but makes more errors.	Kogan and Wallach (1964)
Risk taking/caution	Risk taking is characterized by taking risks even when the odds for success are poor. Caution is characterized by reluctance to take chances except when the probability of success is great.	McKenney and Keen (1974); Schwartz (1972) identified a related style that considers preceptive "generalizing" and receptive"particularizing"
Perceptive-receptive/ systematic-intuitive	The inclination to assimilate data into concepts or precepts previously held (preceptivity) versus the tendency to take in data in raw form (receptivity). The inclination to develop ideas freely from data and to skip from the part to the whole (intuitive).	Gardner (1959)

Leveling/sharpening	Individual variations in assimilation in memory. The leveler tends to assimilate new stimuli into previous categories, while the sharpener tends to differentiate new information from old.	Gardner (1959)
Cognitive complexity/simplicity	Differences in tendency to see the world in a multi-dimensional way. Complexity is characterized by the use of hierarchic integration, while simplicity is shown in the use of dimensions of difference.	Harvey, Hunt, and Schroeder (1961) Kelly (1955)
Scanning/focusing	Entails identification of relevant versus irrelevant information in attempting to solve a problem.	Schlesinger (1954)
Constricted/flexible control	Constructed control shows more susceptibility or distraction; flexible control is characterized by resistance to interference.	Klein (1954)
Broad/narrow category width (equivalence range)	Preference for broad categories containing many items, rather than narrow categories containing few items.	Bruner and Tajfel (1961) Kogan and Wallach (1964); Pettigrew (1958)
Tolerance for incongruous or unrealistic experiences	Indivisual willingness to accept perceptions that vary from conventional experience. Tolerance is characterized by a greater adaptation to unusual perceptions. Intolerance is revealed by the demand for more data before the unusual is accepted.	Klein, Gardner, and Schlesinger (1962)
Strong/weak automatization	Relative ability to perform simple, repetitive tasks compared to what would have been expected from one's general ability level.	Broverman (1964)

Conceptual/perceptual motor dominance	Conceptual dominance is shown by relative specialization of conceptual behavior vs. relative specialization of perceptual motor behavior.	Broverman (1964)
Sensory modality	Reliance on the different sensory modes, especially kinesthetic (leading to figural or spatial thinking), auditory (leading to verbal thinking), or enactive iconic, and symbolic modes.	Bruner, Olver, and Greenfield (1966)
Converging/diverging	Thinking aimed toward logical conclusions and uniquely correct or conventionally best outcomes, versus thinking aimed toward variety and quantity of relevant output.	Getzels and Jackson (1962); Cronback (1968)
Conceptual differentiation	Relative multiplicity of distinctions among concepts (as constrasted to the extent of a single concept's range of reference.	Gardner, Lohrenz, and Schoen (1968)
Compartmentalization	Discrete and relatively rigid categories involving a certain inertia in thinking and possible limitation in production of diverse ideas.	Messick and Kogan (1963); Wallach and Kogan (1965)
Conceptual articulation (conceptual discrimination)	Extent to which stimuli or items of information are treated in dimensional rather than class terms; i.e., extent to which instances of a concept are discriminated from each other in a number of intervals or ordered categories within a concept's range of reference.	Bieri et al. (1966); Schroder, Driver, and Streufert (1967)
Conceptual integration (integrative complexity)	Extent to which categories or dimenions of information are perceived to be integrated in multiple and different ways.	Harvey et al. (1961); Schroder et al. (1967)

APPENDIX 2

Master Cumulative Data Sheet

MALES

ENGINEERS/TECHNICIANS (N =)

	Totals FI	Totals FD
B&W BLOCK		
B&W ICON		
COLOR BLOCK		
COLOR ICON		
TOTALS		

FEMALES

ENGINEERS/TECHNICIANS (N =)

	Totals FI	Totals FD
B&W BLOCK		
B&W ICON		
COLOR BLOCK		
COLOR ICON		
TOTALS		

master

SUBJECT DATA

Males - Field Independent

Subj. #	FD	BB	BI	CB	CI	TOTAL
1	17	5	1	3	6	15
2	17	3	3	3	6	15
3	15	3	1	3	5	12
4	15	2	2	3	5	12
5	14	4	4	2	4	14
6	14	2	4	3	5	14
7	17	5	3	3	5	16
8	17	2	2	3	5	12
9	18	3	5	4	4	16
10	16	6	5	4	4	19
11	18	3	3	2	5	13
12	16	4	2	3	5	14
13	17	4	4	3	5	16
14	15	4	2	3	5	14
15	17	5	5	3	6	19
16	17	4	2	3	5	14
17	16	3	1	3	2	9
18	16	5	3	3	5	16
19	18	2	3	3	6	14
20	17	4	3	3	6	16
21	15	2	3	2	5	12
22	17	3	3	3	5	14
23	15	2	1	3	5	11
24	16	2	2	2	3	9
25	16	1	3	3	3	10
26	15	5	3	3	6	17
27	18	3	4	3	5	15

28	16	3	4	3	5	15
29	17	4	3	5	3	15
30	18	3	3	2	4	12
31	18	5	4	5	5	19
32	18	4	5	1	5	15
33	16	4	3	4	4	15
34	16	4	3	2	5	14
35	18	5	6	5	5	21
36	17	3	2	2	2	9
37	17	5	5	3	4	17

Males - Field Dependent

1	11	4	4	2	4	14
2	8	1	2	1	2	6
3	11	4	0	3	5	12
4	7	3	1	3	4	11
5	4	2	1	1	4	8
6	13	2	1	4	6	13
7	9	2	1	3	4	10
8	1	4	5	5	4	18
9	7	2	2	2	1	7
10	4	2	2	1	0	5
11	12	3	3	3	4	13
12	7	5	4	4	3	16
13	2	5	2	1	5	13

Females - Field-Independent

1	15	4	5	3	5	17
2	15	4	4	2	4	14
3	16	4	3	3	4	14
4	13	1	1	3	4	9
5	14	4	3	3	4	14
6	14	3	5	4	5	17
7	17	5	3	5	3	16

Females - Field-Dependent

1	8	5	5	1	5	16
2	8	4	0	2	5	11
3	8	2	1	2	3	8
4	6	4	1	3	4	12
5	9	6	4	4	4	18

APPENDIX 3

EXPERIMENTER'S PREFACE

Before beginning the experiment, complete the front page of the Information Sheet. DO NOT fill in the bottom of the sheet, which contains space for your name and address, unless you wish to receive your results.

A technician/technologist is anyone who works in a job that requires technical knowledge and/or the application of that knowledge, but has not completed university requirements to be an engineer.

This experiment has been designed to test your recall of information from graphics. After an instruction screen, an introduction screen, and two preliminary graphics screens and multiple choice questions, twelve graphics plus following questions will be shown.

Study the graphics screens carefully. Absorb as much information as possible. Then answer the multiple choice questions.

Turn to the second page of the Information Sheet. This is the answer page for the multiple choice questions. At the top of the page are the answer areas for graphics 0A & 0B. These are the answers for the preliminary test questions. Below these are the answer areas for the twelve multiple choice test questions. Notice that there are two ABCD answer columns. These represent the possible answers for each of the two multiple choice questions which accompany each graphic. Circle only one answer per question.

Are there any questions?

INFORMATION / ANSWER SHEET

DATE: ____________________________

PARTICIPANT'S GENDER: MALE ______ FEMALE ______

PARTICIPANT'S FUNCTION/ROLE: (please check one)

ENGINEER ______ TECHNICIAN/TECHNOLOGIST ______

All information for this experiment will remain strictly confidential. Should wish to know the results of your testing, please fill in the information below and the results of your work will be sent along to your office.

SUBJECT NAME: ____

DEPARTMENT/LOCATION:

____

____

____

SIGNATURE: ____

ANSWER SHEET

Graphic #0a		Graphic #0b	
A	A	A	A
B	B	B	B
C	C	C	C
D	D	D	D

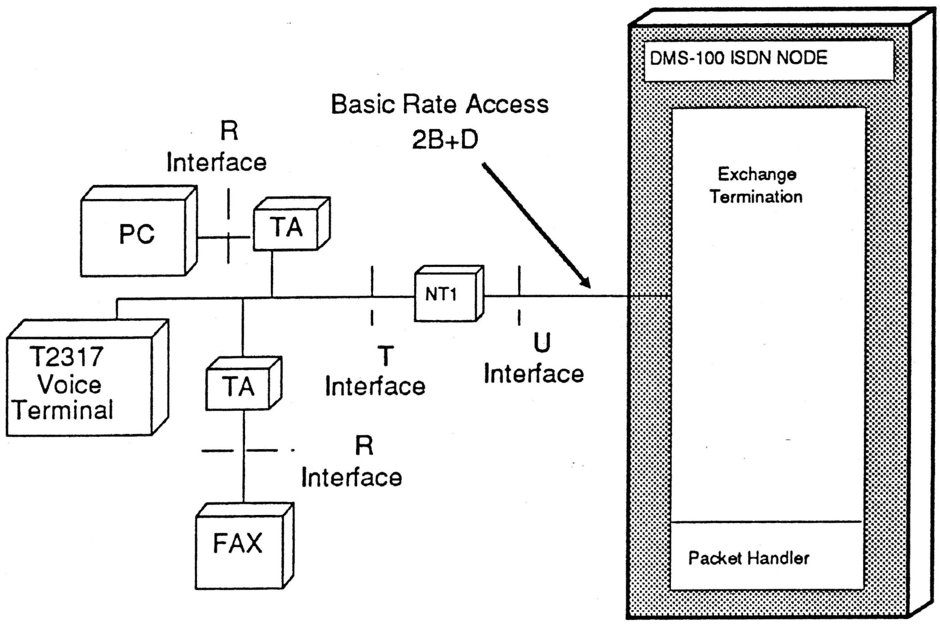
Graphic #1		Graphic #2		Graphic #3		Graphic #4	
A	A	A	A	A	A	A	A
B	B	B	B	B	B	B	B
C	C	C	C	C	C	C	C
D	D	D	D	D	D	D	D

Graphic #5		Graphic #6		Graphic #7		Graphic #8	
A	A	A	A	A	A	A	A
B	B	B	B	B	B	B	B
C	C	C	C	C	C	C	C
D	D	D	D	D	D	D	D

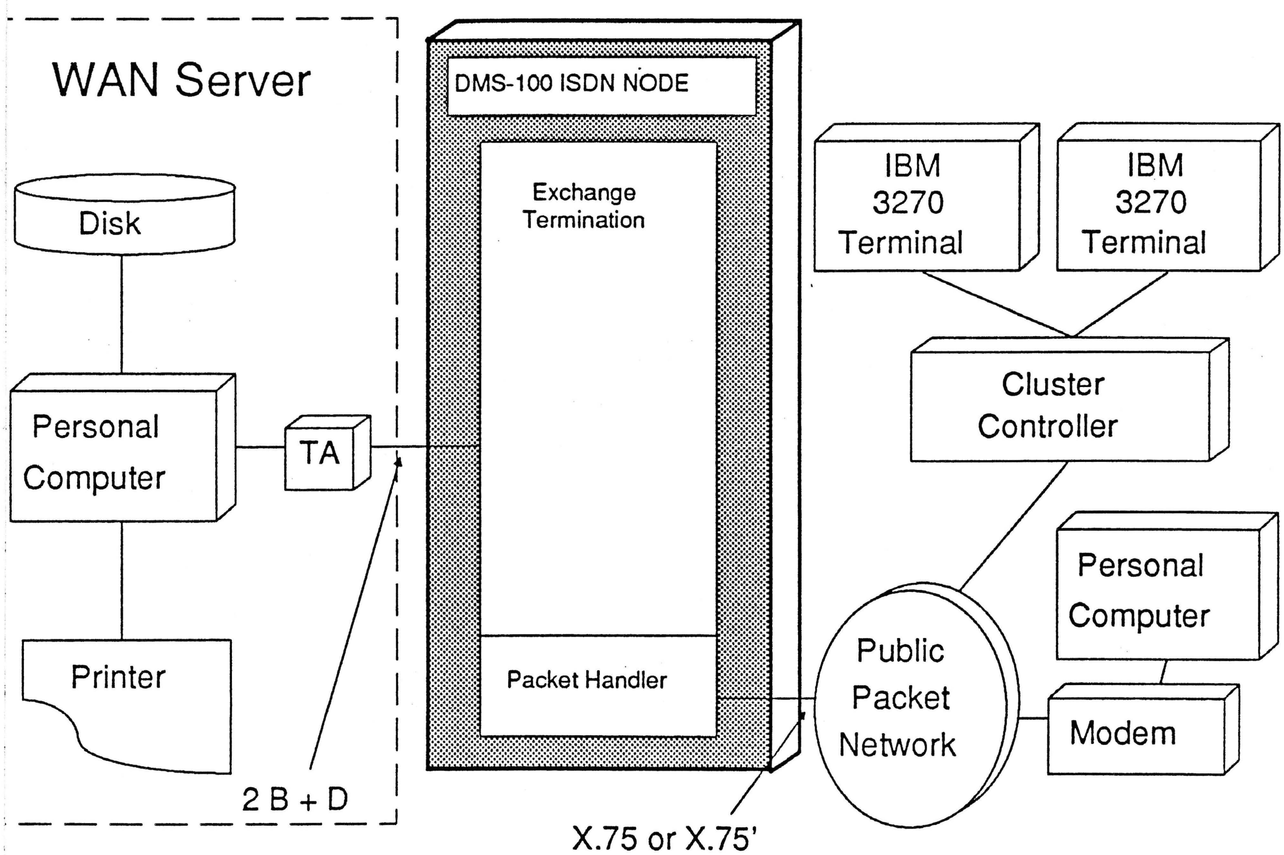
Graphic #9		Graphic #10		Graphic #11		Graphic #12	
A	A	A	A	A	A	A	A
B	B	B	B	B	B	B	B
C	C	C	C	C	C	C	C
D	D	D	D	D	D	D	D

APPENDIX 4 - B & W GRAPHICS

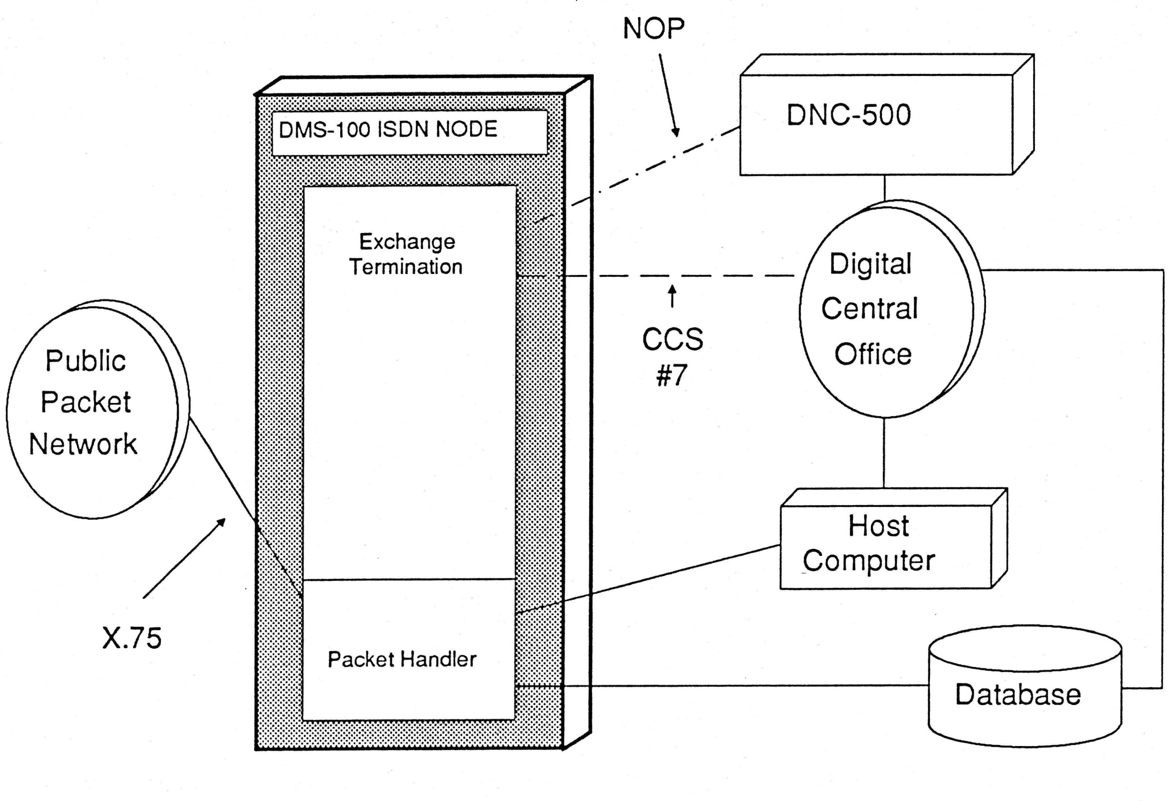
BLK1_BW



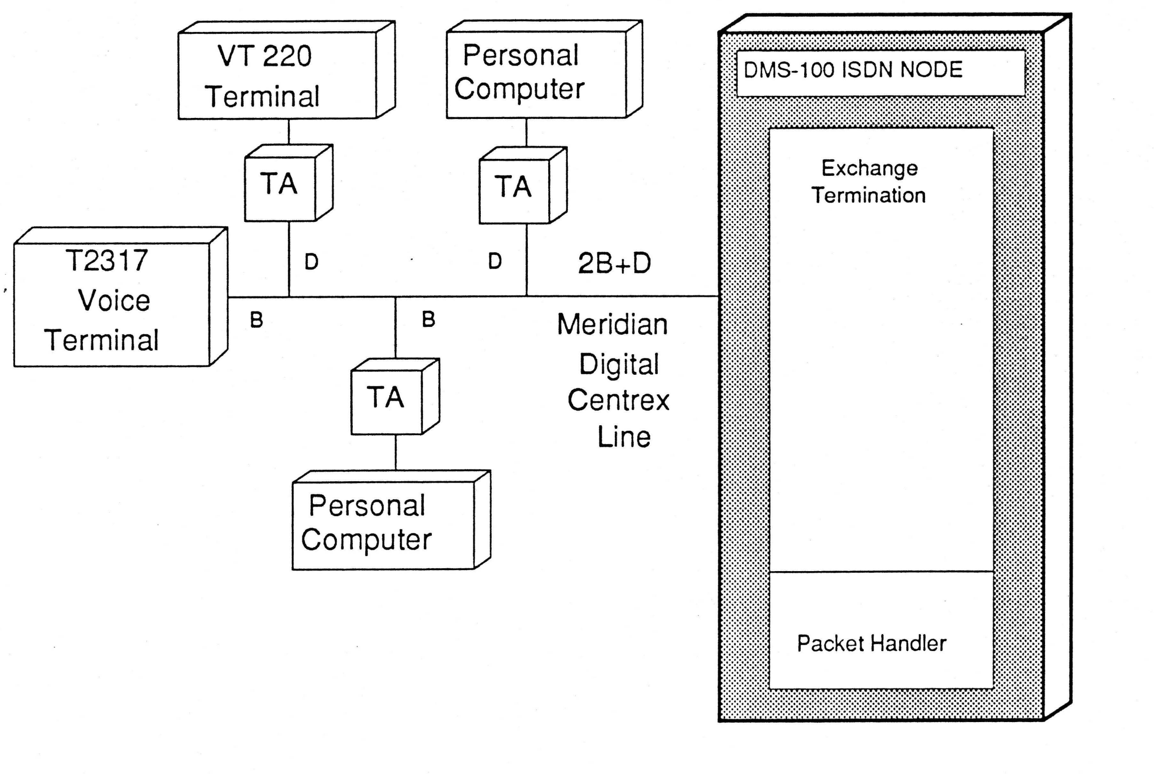
BLK2_BW



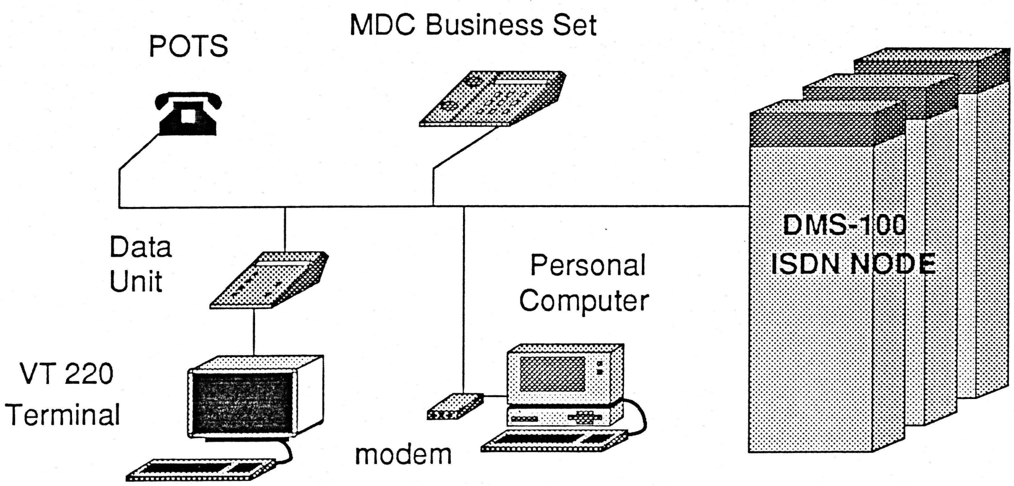
BLK3_BW



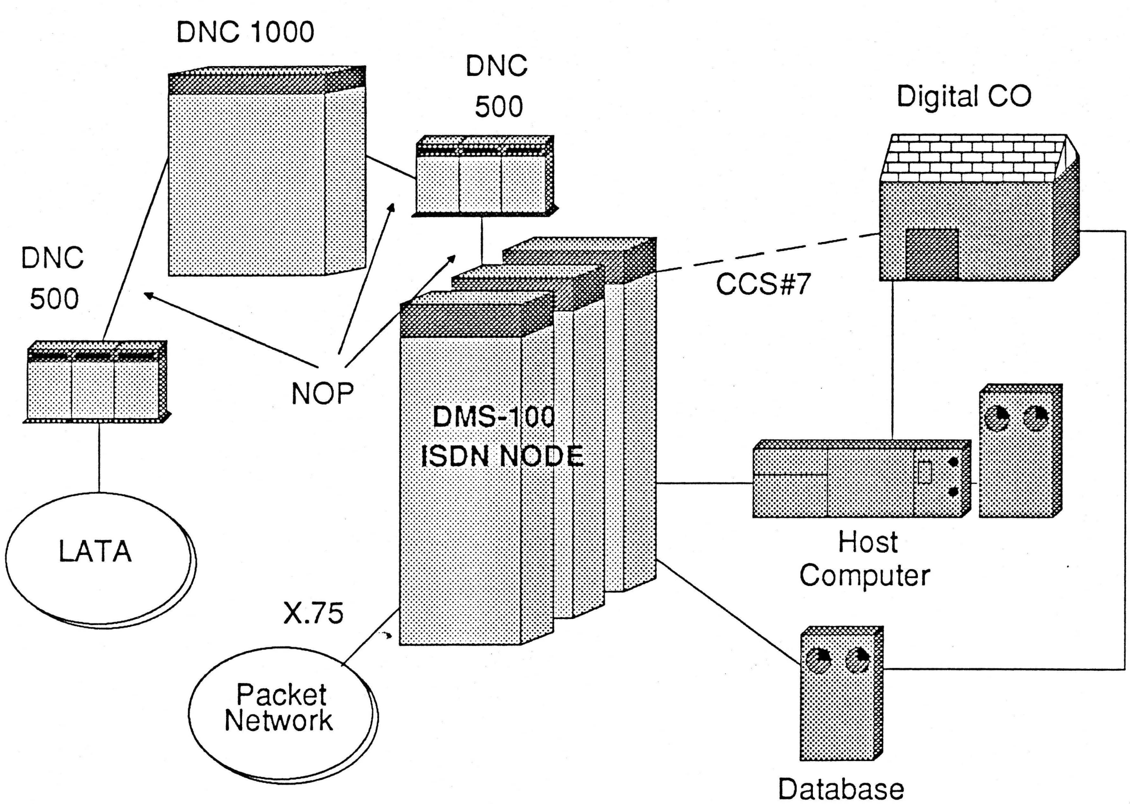
BLK4_BW



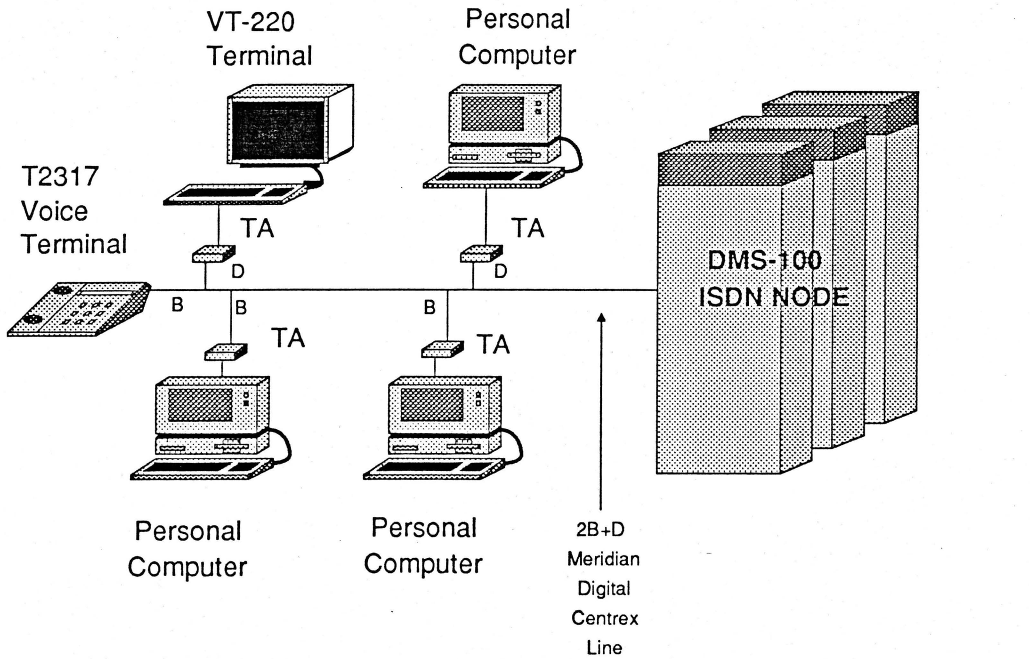
BW_ICON1



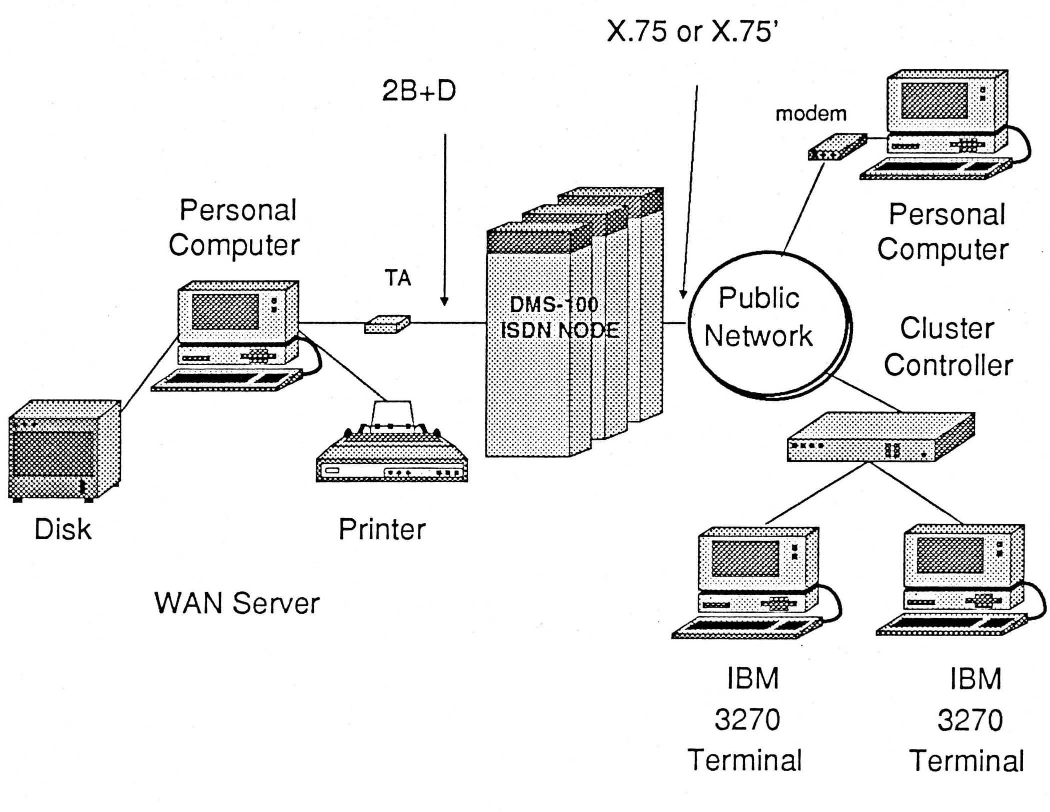
BW_ICON2



BW_ICON3

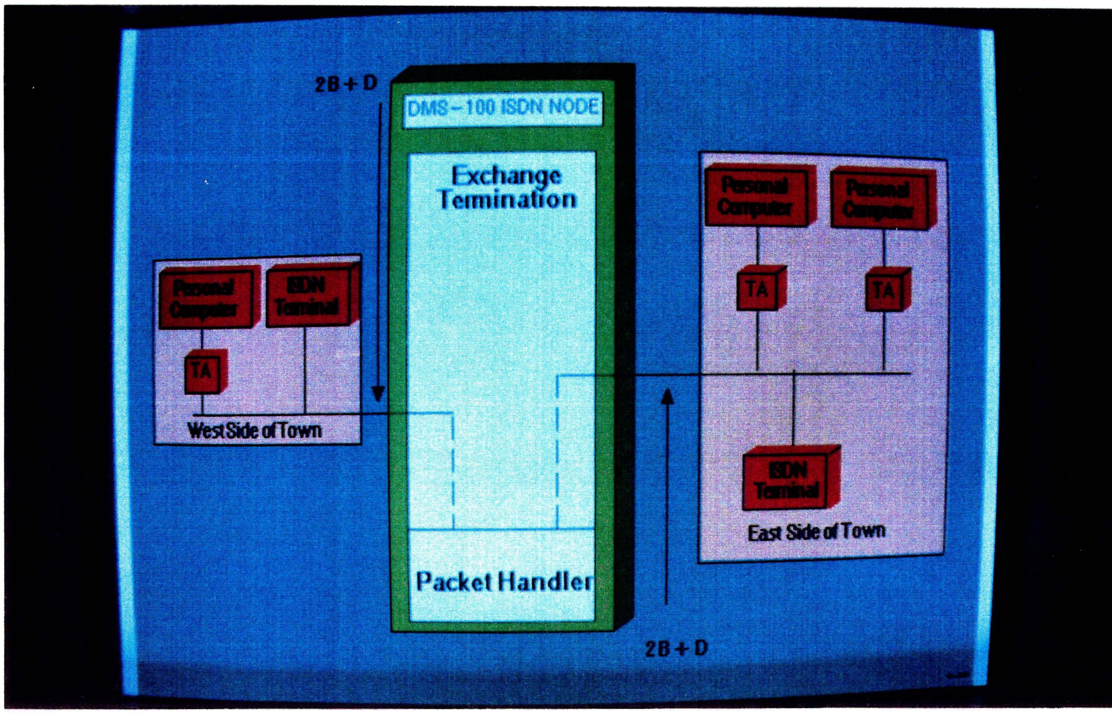


BW_ICON4

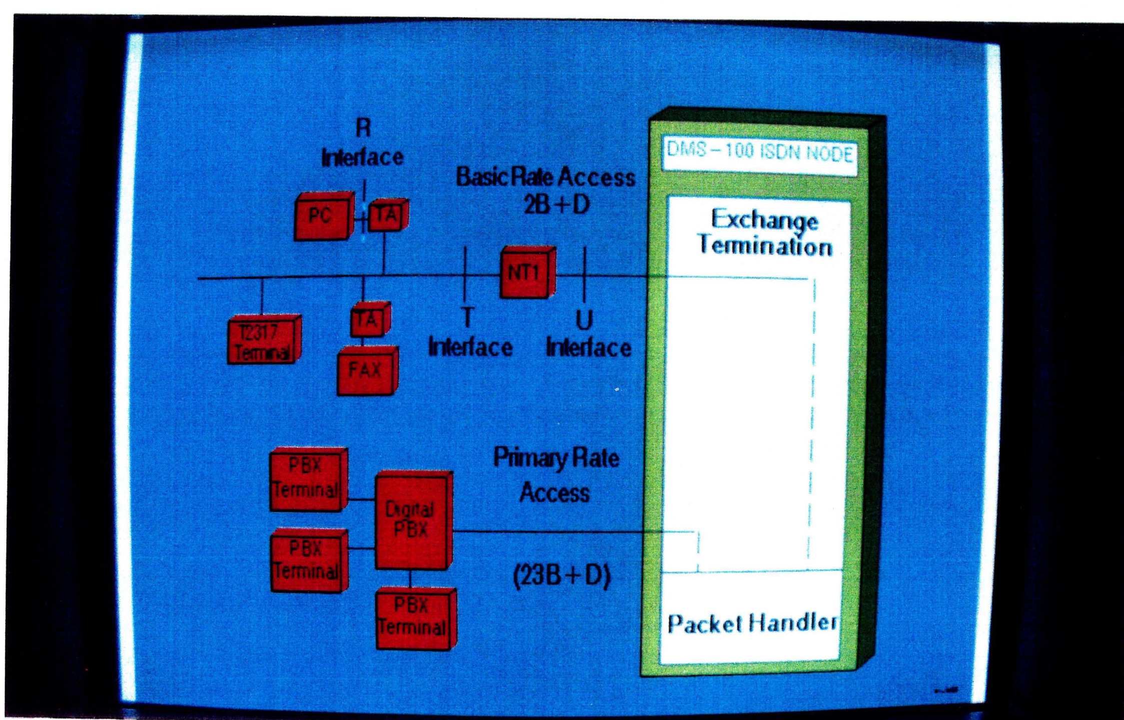


COLOR GRAPHICS

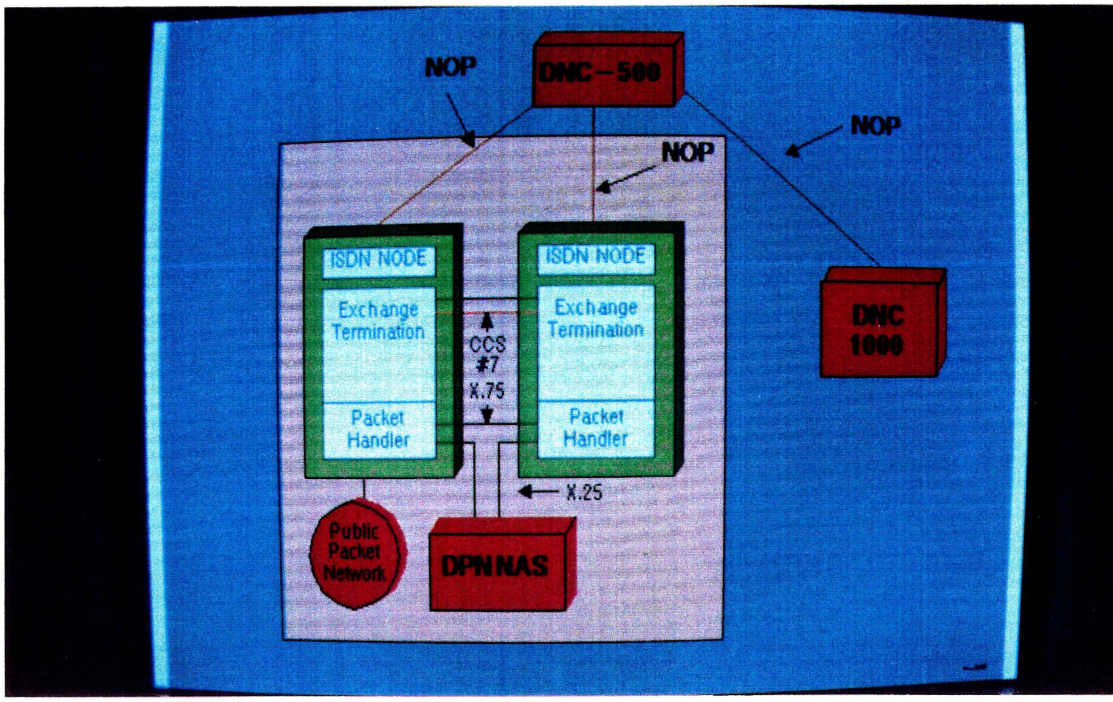
CR_BLK1



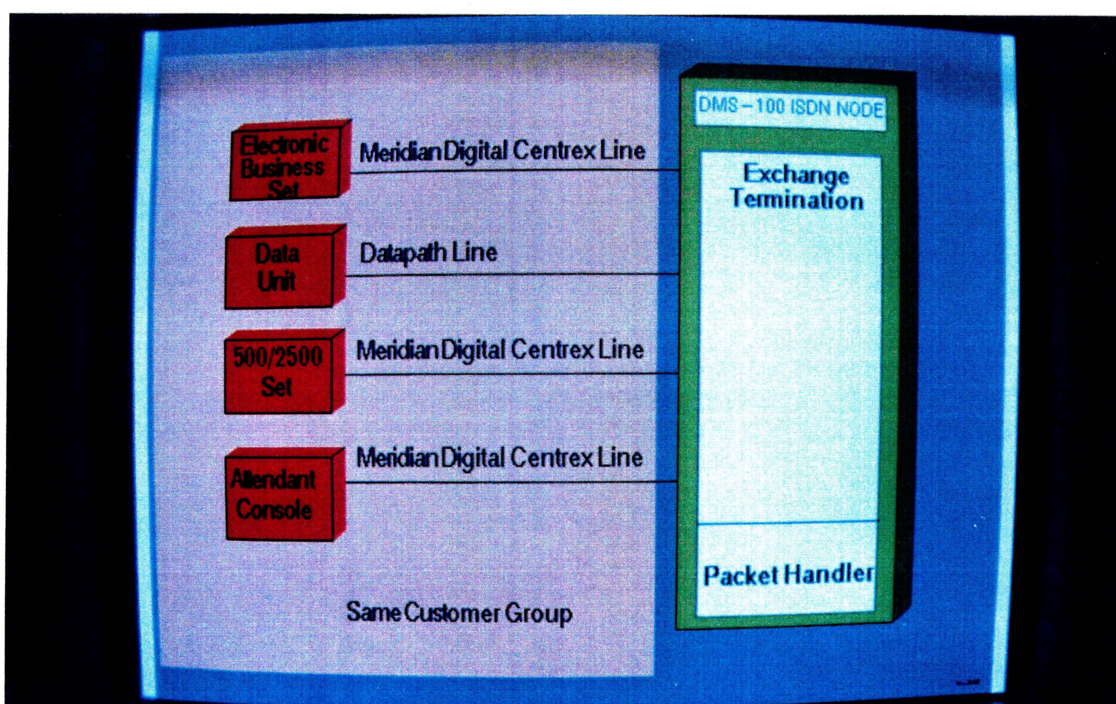
CR_BLK2



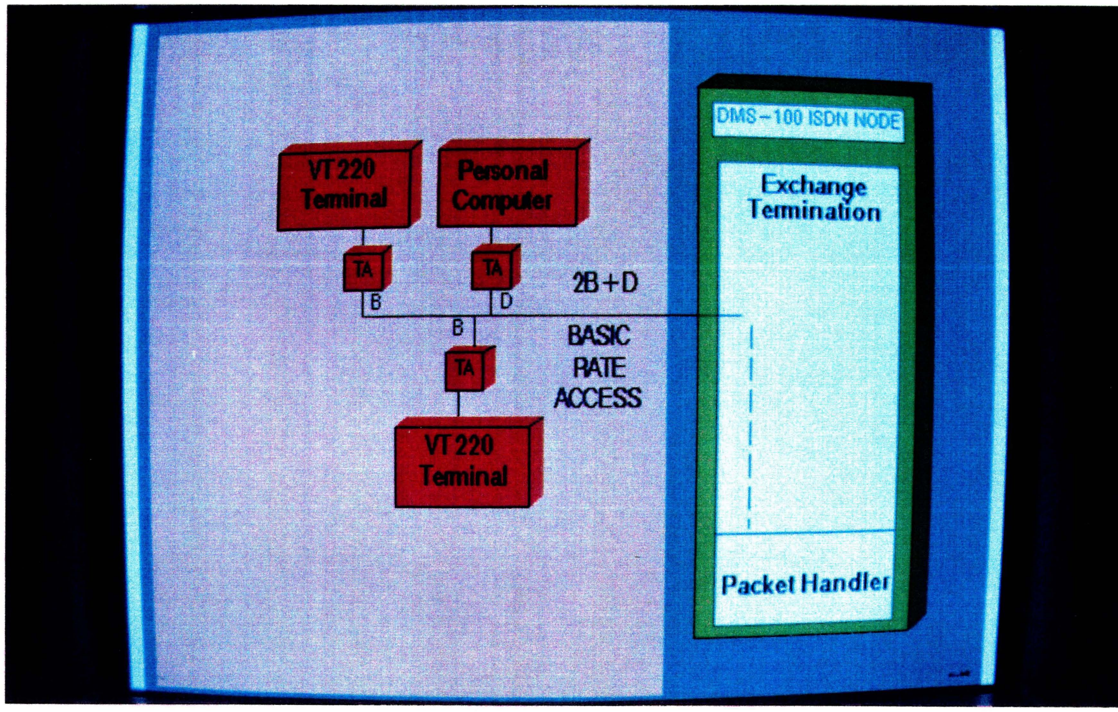
CR_BLK3



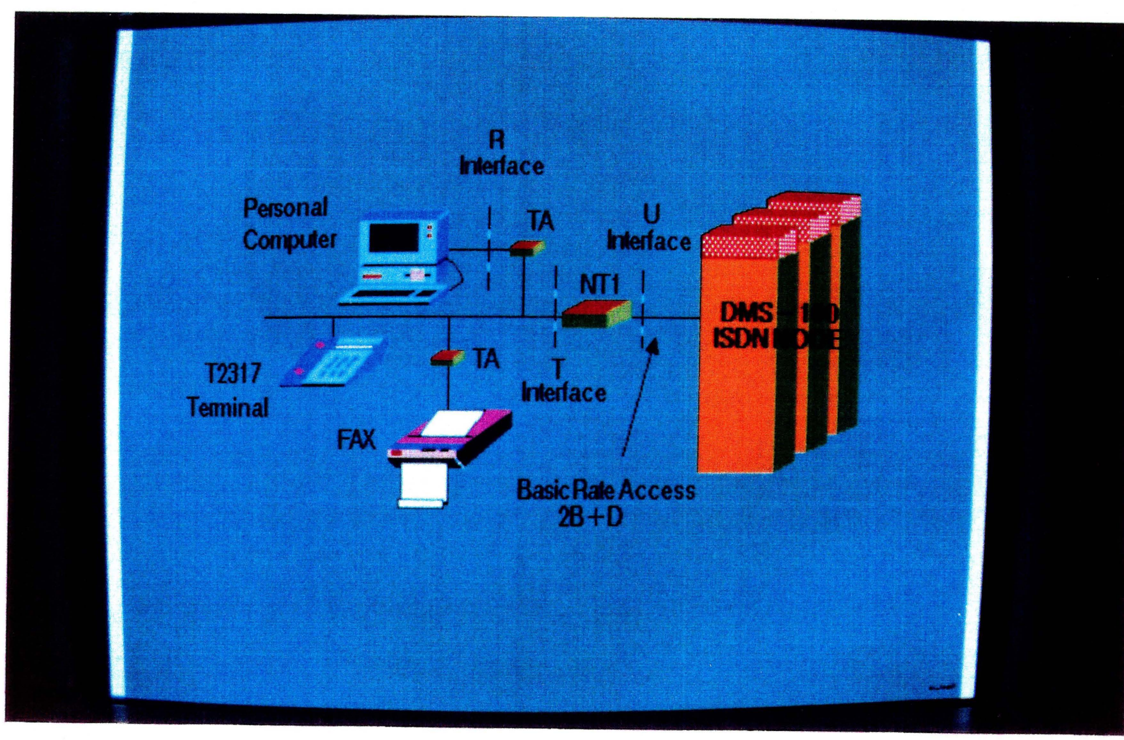
CR_BLK4



CR_BLK5



CR_ICON1

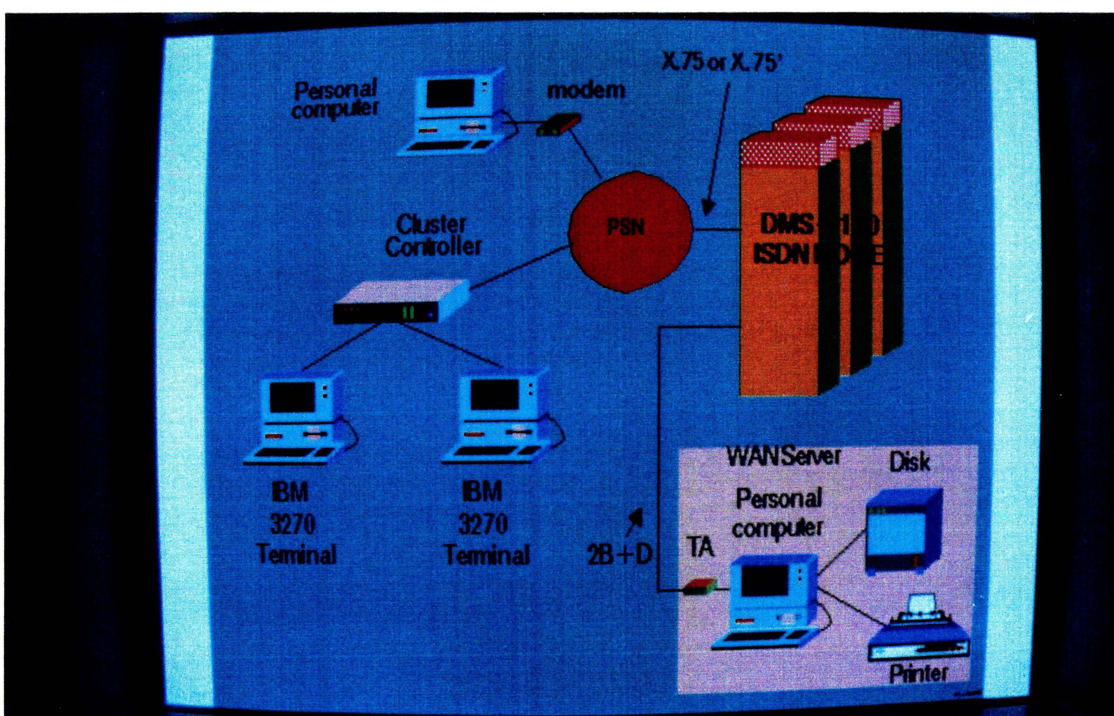


CR_ICON2

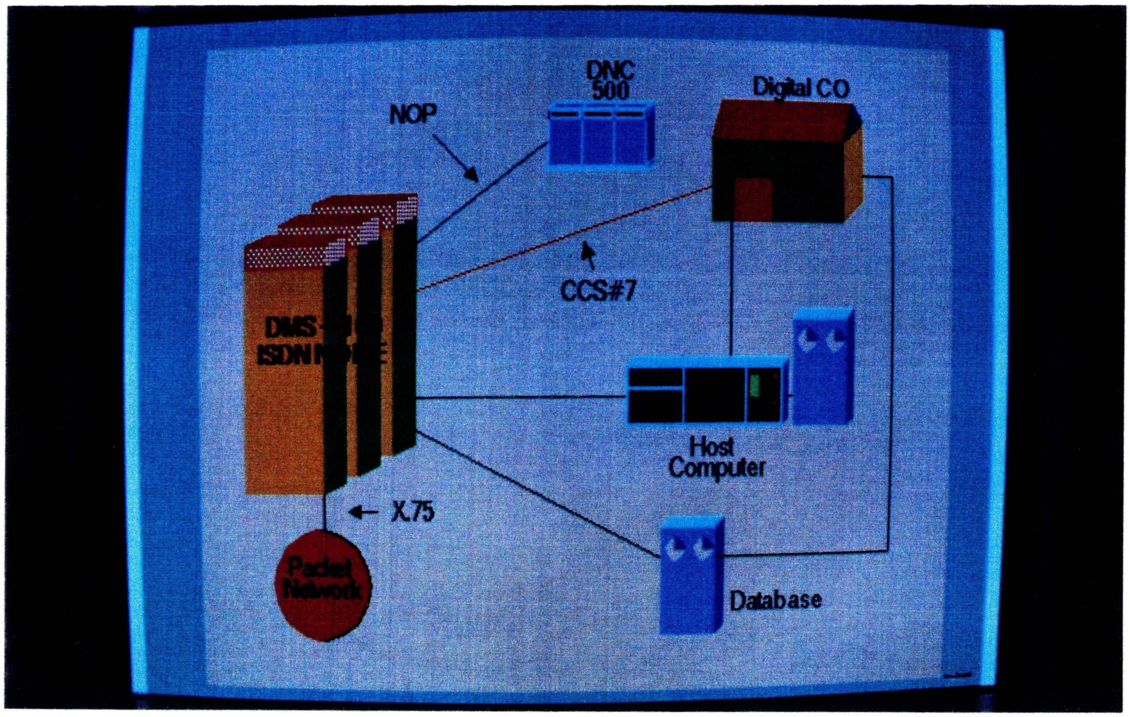
THIS COLOR ICON PICTURE WAS NOT USED IN THE EXPERIMENT,

AND IS NOT AVAILABLE.

CR_ICON3



CR_ICON4


NOP
DNC
500
Digital CO
CCS#7
Host
Computer
X.75
Packet
Network
Database

APPENDIX 5 - EXPERIMENT QUESTIONS for B&W GRAPHICS

BW_BKQ1A

QUESTION

In the previous graphic, which device did the FAX machine use to interface with the 2B+D (Basic Rate Access) line?

a) the terminal adapter
b) the NT1
c) the packer handler
d) the exchange termination

BW_BKQ1B

QUESTION

In the previous graphic, on which one device did the 2B+D (Basic Rate Access) line terminate?

a) the packet handler
b) the terminal adapter (TA)
c) the exchange termination
d) the NT1

BW_BKQ2A

QUESTION

In the previous graphic, which device on the DMS-100 Node terminated the public packet network?

a) the exchange terminator
b) the cluster controller
c) the terminal adapter (TA)
d) the packet handler

BW_BKQ2B

QUESTION

In the previous graphic, which device connected the personal computer to the public packet network?

a) a terminal adapter (TA)
b) a modem
c) a cluster controller
d) a packet handler

BW_BKQ3A

QUESTION

In the previous graphic, which protocol is used to connect the DNC-500 to the DMS-100 ISDN Node?

a) NOP
b) CCS#7
c) X.75
d) X.75'

BW_BKQ3B

QUESTION

In the previous graphic, with which device did the Digital Central Office NOT directly interface?

a) the packet handler
b) the host computer
c) the DNC-500
d) the exchange termination

BW_BKQ4A

QUESTION

In the previous graphic, how many terminal adapters (TA) were present?

a) two
b) three
c) four
d) five

BW_BKQ4B

QUESTION

In the previous graphic, the Meridian Digital Centrex line was a:

a) 23B+D (Primary Rate Access) line
b) DATAPATH line
c) X.75 or X.75' line
d) 2B+D (Basic Rate Access) line

BW_ICQ1A

QUESTION

In the previous graphic, to which device was the VT220 directly connected?

a) the modem
b) the Data Unit
c) the MDC Business Set
d) the DMS-100 ISDN Node

BW_ICQ1B

QUESTION

In the previous graphic, which device was NOT present?

a) a personal computer
b) a T2317 terminal
c) a VT 220 terminal
d) an MDC Business Set

BW_ICQ2A

QUESTION

In the previous graphic, which protocol did the DMS-100 ISDN Node use to connect with the Packet Network?

a) CCS#7
b) X.25
c) X.75
d) NOP

BW_ICQ2B

QUESTION

In the previous graphic, to which switch did the host computer interface?

a) the DNC 1000
b) the DMS-100
c) the DPN 100
d) the DNC 500

BW_ICQ3A

QUESTION

In the previous graphic, how many personal computers were connected to the Meridian Digital Centrex line?

a) two personal computers
b) three personal computers
c) four personal computers
d) five personal computers

BW_ICQ3B

QUESTION

In the previous graphic, which device(s) did NOT have a terminal adapter (TA) connecting it to the Meridian Digital Centrex line?

a) the VT 220 terminal
b) the personal computers
c) the T2317 Voice Terminal
d) the MDC Business Set

BW_ICQ4A

QUESTION

In the previous graphic, which device was connected to the personal computer that was interfaced to the DMS-100 ISDN Node?

a) a printer
b) a cluster controller
c) a modem
d) a tape drive

BW_ICQ4B

QUESTION

In the previous graphic, how many IBM 3270 terminals were interfaced to the cluster controller?

a) one 3270 terminal
b) two 3270 terminals
c) three 3270 terminals
d) four 3270 terminals

EXPERIMENT QUESTIONS for COLOR GRAPHICS

CR_BKQ1A

QUESTION

In the previous graphic, how many terminal adapters (TA) were connected to personal computers?

a) three
b) two
c) one
d) four

CR_BKQ1B

QUESTION

In the previous graphic, how many ISDN terminal(s) were connected to 2B+D (Basic Rate Access) lines?

a) two
b) one
c) three
d) none

CR_BKQ2A

QUESTION

In the previous graphic, which line connected the Digital PBX to the DMS-100 ISDN Node?

a) Meridian Digital Centrex line
b) 23B+D (Primary Rate Access) line
c) 2B+D (Basic Rate Access) line
d) X.75 or X.75' line

CR_BKQ2B

QUESTION

In the previous graphic, how many personal computers were present?

a) four
b) two
c) three
d) one

CR_BKQ3A

QUESTION

In the previous graphic, which protocol was used to interface the DNC-500 to the DNC-1000?

a) NOP
b) X.25
c) X.75
d) CCS#7

CR_BKQ3B

QUESTION

In the previous graphic, DPN NAS was connected to how many ISDN Nodes?

a) three
b) one
c) none
d) two

CR_BKQ4A

QUESTION

In the previous graphic, the 500/2500 Set used:

a) a DATAPATH line
b) a Meridian Digital Centrex line
c) a POTS line
d) an X.25 line

CR_BKQ4B

QUESTION

In the previous graphic, how many Meridian Digital Centrex lines are present?

a) one
b) two
c) three
d) four

CR_BKQ5A

QUESTION

In the previous graphic, what type of line interfaces with the DMS-100 ISDN Node?

a) 23B+D (Primary Rate Access) line
b) packet handler line
c) 2B+D (Basic Rate Access) line
d) X.75' line

CR_BKQ5B

QUESTION

In the previous graphic, which device interfaces the VT 220 to the Meridian Digital Centrex line?

a) a modem
b) an NT1
c) a terminal adapter (TA)
d) a cluster controller

CR_ICQ1A

QUESTION

In the previous graphic, to which type of access line is the T2317 terminal connected?

a) 2B+D (Basic Rate Access) line
b) X.75 access line
c) NOP access line
d) 23B+D (Primary Rate Access) line

CR_ICQ1B

QUESTION

In the previous graphic, which device connects the personal computer to the access line?

a) a modem
b) a terminal adapter (TA)
c) an NT1
d) a Data Unit

CR_ICQ2A

QUESTION

In the previous graphic, which device connected the personal computer to the DMS-100 ISDN Node?

a) a Data Unit
b) a cluster controller
c) a modem
d) a terminal adapter (TA)

CR_ICQ2B

QUESTION

In the previous graphic, how many devices in total were pictured?

a) five
b) six
c) seven
d) eight

CR_ICQ3A

QUESTION

In the previous graphic, which device connected the personal computer (in the Wide Area Network - WAN) to the DMS-100 ISDN Node?

a) a terminal adapter (TA)
b) a cluster controller
c) a modem
d) an NT1

CR_ICQ3B

QUESTION

In the previous graphic, which protocol connected the PSN (public switched network) to the DMS-100 ISDN Node?

a) 2B+D (Basic Rate Access)
b) 23B+D (Primary Rate Access)
c) NOP
d) X.75

CR_ICQ4A

QUESTION

In the previous graphic, which protocol connected the Digital Central Office (CO) to the DMS-100 ISDN Node?

a) NOP
b) X.25
c) X.75
d) CCS#7

CR_ICQ4B

QUESTION

In the previous graphic, how many DNC-500s were present?

a) one
b) two
c) three
d) four

APPENDIX 6 - SHOW 1 PROGRAM LISTING

Picture	Comment	Loc#	Effect	Dir	Location	Size	Target	Speed	Time
THESIS_I.GK1			Replace	Up	Full	Picture	Same	Fast	250
INTERVAL.GK1			Replace	Up	Full	Picture	Same	Fast	3
THESIS_R.GK1			Replace	Up	Full	Picture	Same	Fast	250
INTERVAL.GK1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
CR_INT2.GK1			Replace	Up	Full	Picture	Same	Fast	225
INTERVAL.GK1			Replace	Up	Full	Picture	Same	Fast	3
CR_INT2A.GK1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GK1			Replace	Up	Full	Picture	Same	Fast	3
CR_INT2B.GK1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GK1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
BW_INT1.GK1			Replace	Up	Full	Picture	Same	Fast	225
INTERVAL.GK1			Replace	Up	Full	Picture	Same	Fast	3
BW_INT1A.GK1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GK1			Replace	Up	Full	Picture	Same	Fast	3
BW_INT2B.GK1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GK1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
GRAPH1.GK1			Replace	Up	Full	Picture	Same	Fast	10
INTERVAL.GK1			Replace	Up	Full	Picture	Same	Fast	3
BW_ICON2.GK1			Replace	Up	Full	Picture	Same	Fast	225
INTERVAL.GK1			Replace	Up	Full	Picture	Same	Fast	3
BW_ICQ2A.GK1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GK1			Replace	Up	Full	Picture	Same	Fast	3
BW_ICQ2B.GK1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GK1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
GRAPH2.GK1			Replace	Up	Full	Picture	Same	Fast	10
INTERVAL.GK1			Replace	Up	Full	Picture	Same	Fast	3
BW_ICON3.GK1			Replace	Up	Full	Picture	Same	Fast	225
INTERVAL.GK1			Replace	Up	Full	Picture	Same	Fast	3
BW_ICQ3A.GK1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GK1			Replace	Up	Full	Picture	Same	Fast	3
BW_ICQ3B.GK1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GK1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
GRAPH3.GK1			Replace	Up	Full	Picture	Same	Fast	10
INTERVAL.GK1			Replace	Up	Full	Picture	Same	Fast	3
BLK3_BW.GK1			Replace	Up	Full	Picture	Same	Fast	225
INTERVAL.GK1			Replace	Up	Full	Picture	Same	Fast	3
BW_BKQ3A.GK1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GK1			Replace	Up	Full	Picture	Same	Fast	3
BW_BKQ3B.GK1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GK1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
GRAPH4.GK1			Replace	Up	Full	Picture	Same	Fast	10
INTERVAL.GK1			Replace	Up	Full	Picture	Same	Fast	3
BW_ICON4.GK1			Replace	Up	Full	Picture	Same	Fast	225
INTERVAL.GK1			Replace	Up	Full	Picture	Same	Fast	3
BW_ICQ4A.GK1			Replace	Up	Full	Picture	Same	Fast	125

APPENDIX 6 - SHOW 1 PROGRAM LISTING

Picture	Comment	Loc#	Effect	Dir	Location	Size	Target	Speed	Time
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BW_ICQ4B.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
GRAPH5.GX1			Replace	Up	Full	Picture	Same	Fast	10
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_BLK2.GX1			Replace	Up	Full	Picture	Same	Fast	Key
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_BKQ2A.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_BKQ2B.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
GRAPH6.GX1			Replace	Up	Full	Picture	Same	Fast	10
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BLK4_BW.GX1			Replace	Up	Full	Picture	Same	Fast	225
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BW_BKQ4A.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BW_BKQ4B.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
GRAPH7.GX1			Replace	Up	Full	Picture	Same	Fast	10
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_BLK4.GX1			Replace	Up	Full	Picture	Same	Fast	Key
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_BKQ4A.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_BKQ4B.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
GRAPH8.GX1			Replace	Up	Full	Picture	Same	Fast	10
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_ICON3.GX1			Replace	Up	Full	Picture	Same	Fast	Key
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_ICQ3A.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_ICQ3B.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
GRAPH9.GX1			Replace	Up	Full	Picture	Same	Fast	10
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_ICON1.GX1			Replace	Up	Full	Picture	Same	Fast	Key
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_ICQ1A.GX1			Replace	Up	Full	Picture	Same	Fast	125

APPENDIX 6 - SHOW 1 PROGRAM LISTING

Picture	Comment	Loc#	Effect	Dir	Location	Size	Target	Speed	Time
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_ICQ1B.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
GRAPH10.GX1			Replace	Up	Full	Picture	Same	Fast	10
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BLK1_BW.GX1			Replace	Up	Full	Picture	Same	Fast	225
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BW_BKQ1A.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BW_BKQ1B.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
GRAPH11.GX1			Replace	Up	Full	Picture	Same	Fast	10
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_ICON4.GX1			Replace	Up	Full	Picture	Same	Fast	Key
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_ICQ4A.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_ICQ4B.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
GRAPH12.GX1			Replace	Up	Full	Picture	Same	Fast	10
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_BLK3.GX1			Replace	Up	Full	Picture	Same	Fast	Key
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_BKQ3A.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_BKQ3B.GX1			Replace	Up	Full	Picture	Same	Fast	125
$			Page		Full	Picture	Same	Fast	Key
			End		Full	Picture	Same	Fast	0

APPENDIX 6 - SHOW 2 PROGRAM LISTING

Picture	Comment	Loc#	Effect	Dir	Location	Size	Target	Speed	Time
THESIS_I.GX1			Replace	Up	Full	Picture	Same	Fast	250
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
THESIS_R.GX1			Replace	Up	Full	Picture	Same	Fast	250
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
CR_INT2.GX1			Replace	Up	Full	Picture	Same	Fast	225
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_INT2A.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_INT2B.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
BW_INT1.GX1			Replace	Up	Full	Picture	Same	Fast	225
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BW_INT1A.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BW_INT2B.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
GRAPH1.GX1			Replace	Up	Full	Picture	Same	Fast	10
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BW_ICON2.GX1			Replace	Up	Full	Picture	Same	Fast	225
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BW_ICQ2A.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BW_ICQ2B.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
GRAPH2.GX1			Replace	Up	Full	Picture	Same	Fast	10
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BW_ICON3.GX1			Replace	Up	Full	Picture	Same	Fast	225
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BW_ICQ3A.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BW_ICQ3B.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
GRAPH3.GX1			Replace	Up	Full	Picture	Same	Fast	10
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BLK3_BW.GX1			Replace	Up	Full	Picture	Same	Fast	225
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BW_BKQ3A.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BW_BKQ3B.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
GRAPH4.GX1			Replace	Up	Full	Picture	Same	Fast	10
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BW_ICON4.GX1			Replace	Up	Full	Picture	Same	Fast	225
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BW_ICQ4A.GX1			Replace	Up	Full	Picture	Same	Fast	125

SHOW 2 PROGRAM LISTING

Picture	Comment	Loc#	Effect	Dir	Location	Size	Target	Speed	Time
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BW_ICQ4B.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
GRAPH5.GX1			Replace	Up	Full	Picture	Same	Fast	10
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_BLK2.GX1			Replace	Up	Full	Picture	Same	Fast	225
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_BKQ2A.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_BKQ2B.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
GRAPH6.GX1			Replace	Up	Full	Picture	Same	Fast	10
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BLK4_BW.GX1			Replace	Up	Full	Picture	Same	Fast	225
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BW_BKQ4A.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BW_BKQ4B.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
GRAPH7.GX1			Replace	Up	Full	Picture	Same	Fast	10
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_BLK4.GX1			Replace	Up	Full	Picture	Same	Fast	225
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_BKQ4A.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_BKQ4B.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
GRAPH8.GX1			Replace	Up	Full	Picture	Same	Fast	10
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_ICON3.GX1			Replace	Up	Full	Picture	Same	Fast	225
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_ICQ3A.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_ICQ3B.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
GRAPH9.GX1			Replace	Up	Full	Picture	Same	Fast	10
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_ICON1.GX1			Replace	Up	Full	Picture	Same	Fast	225
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_ICQ1A.GX1			Replace	Up	Full	Picture	Same	Fast	125

SHOW 2 PROGRAM LISTING

Picture	Comment	Loc#	Effect	Dir	Location	Size	Target	Speed	Time
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_ICQ1B.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
GRAPH10.GX1			Replace	Up	Full	Picture	Same	Fast	10
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BLK1_BW.GX1			Replace	Up	Full	Picture	Same	Fast	225
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BW_BKQ1A.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
BW_BKQ1B.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
GRAPH11.GX1			Replace	Up	Full	Picture	Same	Fast	10
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_ICON4.GX1			Replace	Up	Full	Picture	Same	Fast	225
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_ICQ4A.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_ICQ4B.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
			Slide	Up	Full	Picture	Same	Fast	1
GRAPH12.GX1			Replace	Up	Full	Picture	Same	Fast	10
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_BLK3.GX1			Replace	Up	Full	Picture	Same	Fast	225
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_BKQ3A.GX1			Replace	Up	Full	Picture	Same	Fast	125
INTERVAL.GX1			Replace	Up	Full	Picture	Same	Fast	3
CR_BKQ3B.GX1			Replace	Up	Full	Picture	Same	Fast	125
$			Page		Full	Picture	Same	Fast	Key
			End		Full	Picture	Same	Fast	0

APPENDIX 7 - CORRECT ANSWERS

SHOW1

1	BW_ICON2	C B	B C	CR_BLK4	7
2	BW_ICON3	B C	A D	CR_ICON3	8
3	BW_BLK3	A A	A B	CR_ICON1	9
4	BW_ICON4	A C	A C	BW_BLK1	10
5	CR_BLK2	D A	D A	CR_ICON4	11
6	BW_BLK4	A D	A D	CR_BLK3	12

SHOW2

1	CR_BLK2	D B	C B	CR_BLK4	7
2	BW_ICON2	B C	A A	BW_BLK3	8
3	BW_ICON4	B A	D B	BW_BLK4	9
4	CR_ICON4	A B	C A	BW_BLK1	10
5	CR_BLK1	A A	D A	CR_ICON3	11
6	BW_ICON1	B B	A D	CR_ICON4	12

answers

APPENDIX 8

```
* * * *   M U L T I P L E   R E G R E S S I O N   * * * *

Equation Number 1     Dependent Variable..   TOTAL

------------------ Variables in the Equation ------------------

Variable                  B          SE B         Beta          T  Sig T

GENDER               .27177        .43857       .03140       .620  .5380
CD                  1.09811        .18413       .32168      5.964  .0000
CI                   .89866        .16005       .31230      5.615  .0000
BI                  1.04180        .13600       .43600      7.661  .0000
FD             6.787005E-03        .04444  8.8377E-03       .153  .8792
BB                   .80990        .16271       .29394      4.978  .0000
(Constant)           .11846        .98130                   .121  .9044

End Block Number   1   All requested variables entered.
-------------------------------------------------------------------------
```